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Electronic Business®

Printed circuit board makers: The search for the right stuff

The restructuring of the U.S. resistor industry

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INTRODUCING
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VOL. 13, NO. 17 SEPTEMBER 1, 1987

FOR THE MANAGEMENT TEAM IN ELECTRONICS, COMPUTER AND SYSTEMS COMPANIES

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VBPA ABP

The semiconductor industry is back in the black again

Don't look for a 1984-style boom, but there is reason to forecast sustained second-half growth

The U.S. semiconductor industry appears to be firmly in the black, after recording continued growth through the second quarter of 1987. In fact, the industry is now operating at a $10 billion per year run rate, according to the Semiconductor Industry Association. Business must be improving; semiconductor manufacturers have not seen a run rate like that since the boom of 1984.

Recent forecasts from Cahners Economics are equally optimistic. Cahners is forecasting the second quarter of 1987 to show total U.S. semiconductor sales of $2.45 billion, up from $2.24 billion in the first quarter, and also up from 1986's second quarter figure of $2.20 billion. Third quarter 1987 is expected to drop slightly to $2.42, but then rebound strongly to end the year with $2.69 billion in sales.

Another measure of growth shows semiconductor distributor shipments also very positive. Cahners forecasts second quarter 1987 distributors' shipments at $573.3 million, up dramatically from first quarter's figure of $473.6 million. Compared with the the 1986 second quarter figure of $592.3 million, however, distributor's shipments are down somewhat. For the remainder of the year, Cahners predicts that distributors' shipments will continue to increase, growing to $600.1 million in the third quarter and to $643.4 million in the fourth quarter.

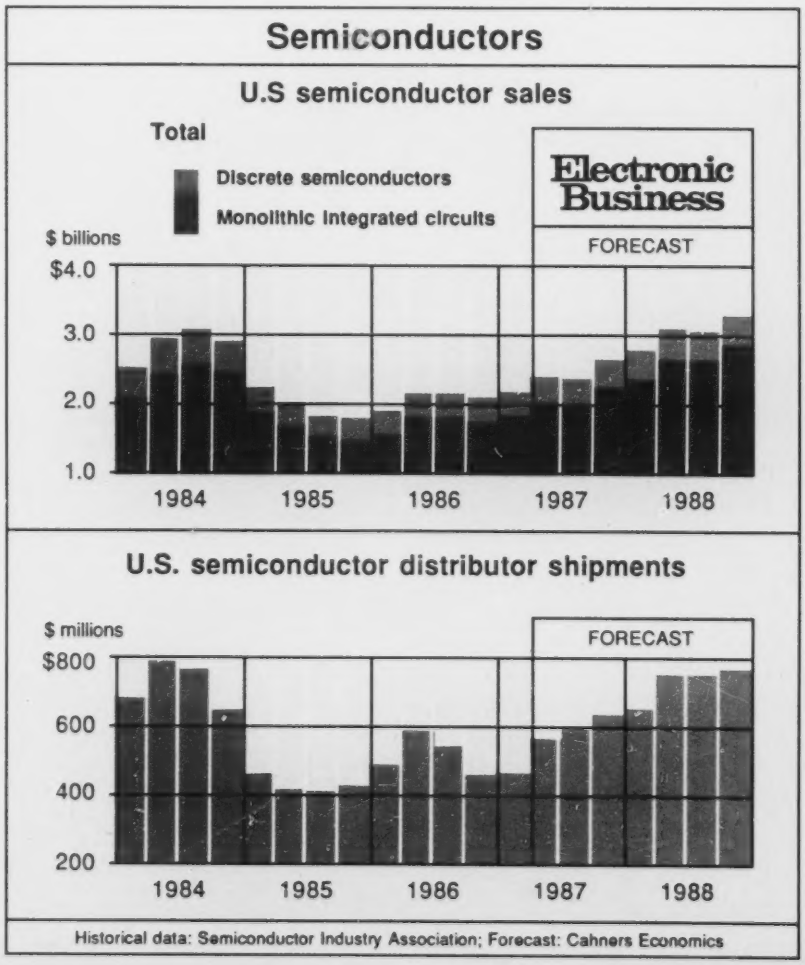
With two strong growth quarters behind it this year, some semiconductor pundits are beginning to treat the recovery as something real, rather than a panic-buying phenomenon. It would seem that inventory stockpiling, the scourge of the industry several years ago, has decreased dramatically, as business in the user industries (particularly computer and industrial) continues to show real growth.

Traditionally conservative — and therefore often accurate — market research firm In-Stat Inc. is "relatively optimistic" regarding business this year. Says vice president William Groves: "I think the business is real. I've seen some people get excited about the growth because it is reminiscent of olden times. Overall, this year is good, but it is not another 1984."

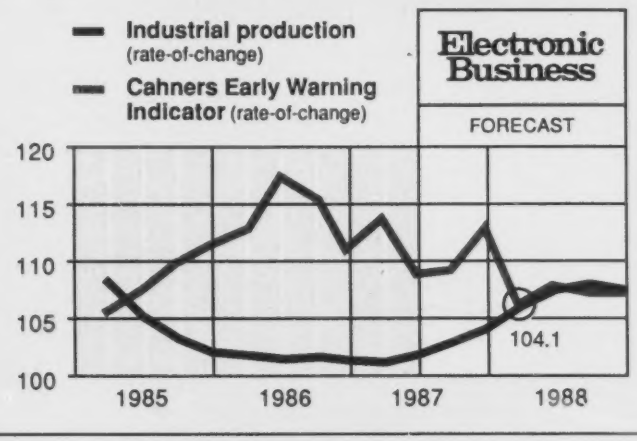
This year might not be another 1984, but it is strong enough for some semiconductor companies to return to profitability. Last year's second quarter results had almost all of the major companies in the red, including Intel Corp. with a $20.4 million loss, Advanced Micro Devices Inc., with a $28 million loss, and National Semiconductor with heavy losses as well. This year's second quarter calendar year results brought AMD and National into the black, and gave Intel record quarterly growth of 43%.

One reason for the growth, certainly, is the strength of the personal computer business.

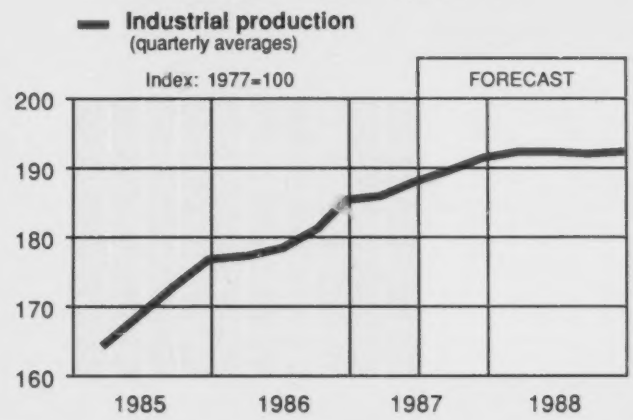
VALERIE RICE



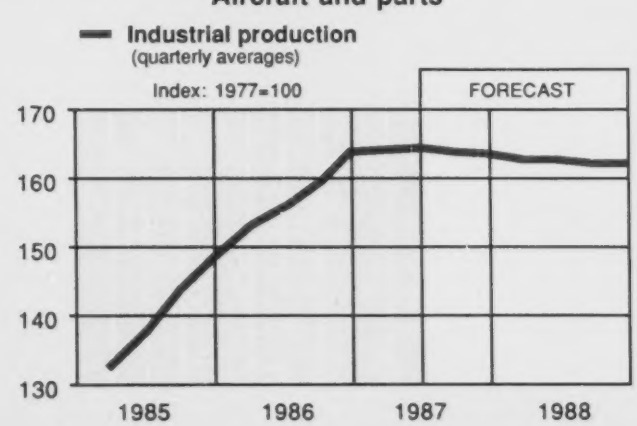
Economic indicators



Defense and space equipment



Aircraft and parts



Historical data: U.S. Commerce Department; Forecast: Cahners Economics

Steady growth expected

The United States Index of Industrial Production, a coincident indicator of the U.S. economy, has been climbing steadily since the summer of 1986. The fourth quarter was up 0.7% from the prior quarter bringing yearly production up 1%. This year, modest gains are expected to continue through mid-year (first quarter production rose by 0.6%) with sharper increases in industrial production expected in the third and fourth quarters.

The Cahners Early Warning Indicator (CEWI) is a weighted average of housing starts, the Dow Jones Industrial Stock Index and the money supply (M2) — deflated by the Consumer Price Index. It forecasts probable business cycles about 12 months in advance. The black curve is a plot of the 12-month rate of change Index of Industrial Production. That is, its change over a 12-month period can be determined by comparison with the line at 100. For example, the 104.1 level forecasts using the CEWI for the end of this year indicates that the average for all of 1987 should be 4.1% above 1986.

More information can be obtained from Elizabeth Baatz, economist, Cahners Economics Department, 275 Washington St. Newton, Mass. 02158.

Defense and space equipment

Budget reductions have squeezed growth in the defense and aerospace markets since the end of 1984 and will continue to act as a restraint throughout 1987-1988. First-quarter production was up 0.5% from the level in the previous three months and outpaced the year-ago quarter by 5.1%. Peak growth rates for this cycle were about twice as high. Cutbacks have taken their greatest toll on military equipment procurement and R&D funding, which together account for about 37% of total spending. The cuts have taken the form of stretched-out program schedules and a growing shift toward electronic modernization rather than new equipment development. Look for production to continue on a slow climb, increasing 4.7% for all of 1987 and just 1.9% in 1988.

Aircraft and parts

Until recently, the aircraft and parts industry had been growing at a healthy pace. But reports for early 1987 provided evidence that the market expansion has begun to lose steam. Production in the first three months of this year showed a gain of just 0.4% over the prior quarter, the smallest advance since the beginning of 1984. Growth on a year-to-year basis, meanwhile, slowed to 7.5% from 10.2% in the final three months of 1986. Declines in the defense sector are expected to produce a further moderation in the marketplace over the next 12 to 18 months.

services company, says: "The Fiat-IBM alliance is significant. They are positioning themselves to be present in a market which is still in its infancy — but with good prospects for growth in Italy and elsewhere in Europe."

Kees Mulder, senior telecommunications consultant at Link Resources Inc.'s European office in London, believes that IBM will have its work cut out for it to become established as a full-fledged player in value-added networks (VANs) in Italy. "It's not just a matter of deregulating a government telecommunications monopoly in Italy," Mulder explains. "The problem is to coordinate a host of bureaucratic organizations involved in Italian telecoms. It's a real melting pot over there."

At Dataquest, Ted Richardson says: "IBM has adopted a pragmatic approach in joining forces with Fiat because it could not have achieved this result on its own. IBM is trying to present itself as more European in order to seize opportunities that it could not grasp as a U.S. group."

British inroads

In another move, IBM is stepping into Britain's fast-growing cellular telephone market, enabling subscribers to access its data networks via portable computers in their cars. Users of Cellnet and Vodafone, the two British cellular networks, will be able to use electronic mail and financial information services. An IBM official in London says: "We are continually looking for new ways to help our customers hook up to our network. -

Although IBM launched its British VAN early last year, customers so far had only limited access to its international networks which cover Israel, Japan, the United States and 13 European countries. Now, IBM is offering British users wider opportunities to log on. It is giving particular emphasis to extending its trade data interchange service, which allows transmission of business documents relating to buying and selling.

IBM hopes this strategy will enable it to play a bigger role in the British market for such services where ICL Ltd., Britain's largest national computer company, is strong. Big Blue is currently equipping its computer center in Warwick, England, to make this its second European control center for VANs. The other is located at Zoetermeer in the Netherlands.

JACK GEE

MILITARY

Core hangs onto its niche in military electronics

Everyone wants to write the definitive obituary for core memory, but core is one technology that won't die

Let's not kid ourselves. Core memory, the primary computer storage medium in the 1960s, is hardly putting semiconductor makers on the endangered list. Commercial applications dried up years ago, and now even the military is forsaking core for chips.

But try telling that to the half-dozen vendors still making a lucrative living at it. Dean Knutson, manager of products and programs for Ampex Corp.'s Computer Products Division in El Segundo, Calif., sums up their never-say-die attitude: "Our goal is to be the one that turns out the lights, whenever that is," he declares.

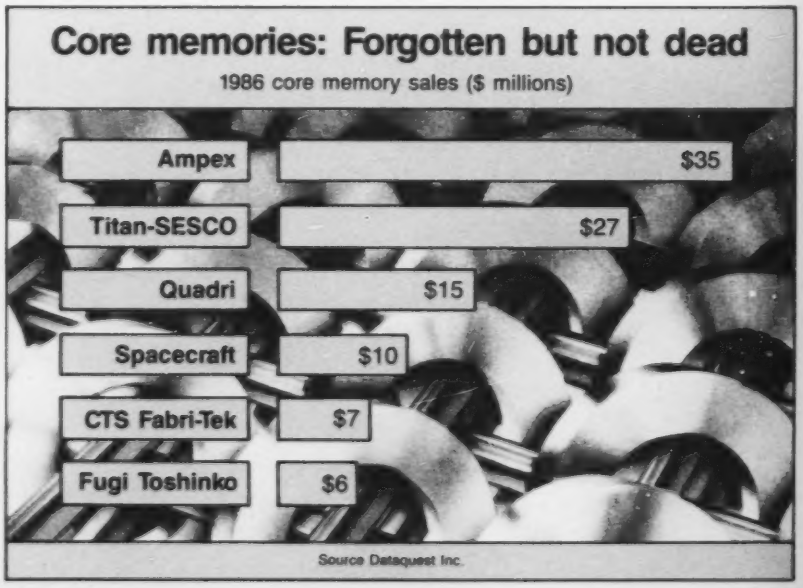
It may not be this century. Core is central to many military programs running well into the 1990s. It is easy and inexpensive to "harden" core against nuclear radiation, and little else can equal its ability to store data in what the military calls "severe environments." And core makers pin hope on new programs like the small intercontinental ballistic missile (SICBM) and the Strategic Defense Initiative (SDI), where core's nonvolatility and natural radiation resistance may prove crucial.

Lobbying effort

To try to enhance core's prospects with these programs, Ampex's Knutson is feeling out support for action that core makers have never taken before: a concerted lobbying effort for Defense Department funding of new core development.

Core stores binary data on microscopic ferrite rings that are cut out of tape and strung on wire like beads. Signals along one wire flip the memory from "zero" to "one" and back; another wire "reads" that condition. Its prime plus-point is its nonvolatility; power can be lost and the memory remains intact, as witnessed by investigators who recovered data from the core memories in the IBM AP101 computers on the Challenger space shuttle after the equipment had been blown up, burned and soaked in salt water.

The first commercially available



core appeared in 1956, and soon became the mainstay of computer memory. It also remembered the order of songs requested on jukeboxes. By the early 1970s, core had grown to what some say was a billion dollar a year business. But with the emergence of semiconductors, core lost markets wholesale, and by 1980, had been almost entirely replaced in commercial use. Today, Dataquest, a San Jose, Calif., market research firm, puts worldwide shipments — almost all military — at about $100 million annually. "We were a little surprised to find it was as large as it was," says analyst Robert Gaskin.

Profitability is surprisingly high too, although not one vendor will disclose just how high. "Core made the majority of our money last year," says Bryan Rickard, vice president for memory and power-supply programs at Titan Corp.'s Severe Environment Systems Co. (SESCO) in Chatsworth Calif. Adds Harold Ergott, president of Tempe, Arizona-based Quadri Corp.: "It has been profitable enough for us to use the cash for other businesses."

Core has hovered near the $100 million level for four or five years, and insiders reckon it will stay there for another five. "They've kept it alive with miniaturization of the core itself," explains Gerald Holland, a design section manager with Litton Industries Inc.'s Guidance and Control Systems Division.

Three decades ago, when one scientific journal was predicting core's imminent demise, a small core's inside diameter was 50 millionths of an inch (mils). Today, 13 mil is the standard, 9 mil is common and 6 mil is in the labs at Ampex. Consequently, vendors that in 1970 were gleeful over packing 8k x 18 (8,000 18-bit words) onto a core array now put 64k x 18 modules in the same 6 x 9 x 1.4-inch package, the de facto standard for the likes of the AYK-14 airborne computer developed by Control Data Corp. during the mid-1970s.

How dense can you get

How much higher densities can go is questionable. Modules of 128k capacity using 9-mil cores are near production; Ampex is studying 6-mil cores, but has no plans to produce them yet. The real problem is stringing such miniscule rings, a task that remains labor intensive, and is carried out mostly in the Far East since fully automated stringing does not exist.

Core's military use is widespread. Besides the space shuttle avionics, core appears in the IBM systems aboard the B-1B bomber. Litton features it in the Cruise missile's inertial navigation unit, and in the electronic-warfare system of the F-4 plane. Core stores data in sonar and in satellites. More recently, a 64k radiation-hardened module was incorporated into ground control of MX missiles.

But semiconductors — notably electrically erasable read-only memories (EEPROMs) are gaining ground despite their slower data-writing speeds and limited number of write cycles. The chips exceeded core in price/performance perhaps three years ago. Several contractors have abandoned core already; Unisys Corp.'s military-computer divisions claim core's reliability and speed were inferior. Honeywell Inc. adds core's cost and bulk to Unisys' reasons for discontinued use. Recently, British Aerospace Plc converted the main computer in its Rapier ground-air defense system to EEPROMs.

The core market has hovered near the $100 million level for about five years, and insiders reckon it will stay there for another five

Others are following. IBM's Federal Systems Division in Owego, N.Y., won awards this year to design chips into the shuttle computers by 1989. Big Blue is also retrofitting semiconductors to Airborne Warning and Control System (AWACS) units.

Vendors appear unperturbed; they have been living with core's end for decades. Few remain entirely dependent on the older technology: Ampex's Computer Products Division now derives 60% of its sales from display terminals, and SESCO, with just over half its revenue from core, gets another 33% from ruggedized computers and 5% from chips. Both firms were virtually 100% core 15 years ago.

One player, CTS Fabri-Tek Inc. of Minneapolis, is itself experimenting with EEPROMs, and has put half a megabyte in semiconductors into the 6 x 9 x 1.4-inch package it is sending out for evaluation soon. According to Sherm Beyl, sales and marketing manager, this diversification plan contains a message: "We're memory-system designers, not just core stringers," he asserts.

Others, like Quadri, are studying bubble memory as well as winning competitions for the specialized core that makes up to 15% of Quadri's sales and helps fuel the 35% annual revenue growth that president Ergott reports. "What we see increasing is radiation-hardened nondestructive read-out [NDRO] memory. That is a wedge of growth that will be on top of our standard core business," he says. He expects this wedge to grow at least 20% annually, since hardened core memories maintain strong cost advantages over radiation-resistant semiconductors.

Another hope for core vendors is bulk storage, the multimegabyte mass memory needed for highly computational work, like satellite image processing or missile threat assessment. Suppliers hope core will be considered to replace disk drives. SESCO makes a 1024k x 18 mass memory; Ampex's 1-megabyte Megastore-9 is in product qualification.

Nowhere will radiation-hardening and mass memory be more critical than in SDI, or Star Wars, programs and in prospects like the SICBM and the rail-mounted MX missile proposal. "If the SICBM goes core, then core has a real bright future," says Ampex's Knutson.

But the services may not consider core exotic enough; vendors complain that they can't even get papers published at technical conferences. "It doesn't have a modern ring to it," concedes SESCO's Rickard. Consequently, any lobbying efforts for Pentagon funding, if they come to pass, may be too little, too late.

Meanwhile, core players concentrate on today's programs. Ampex sees business dipping slightly in 1988 because of program stretch-outs but picking up again in 1989. And beyond the 1990s? The firms that jokingly claim to be on the leading edge of a trailing-edge technology insist that the demise of core memory, like Mark Twain's death, has been greatly exaggerated. Yet they accept the inevitable: "There's got to be a day when these things go to the museum," says Knutson.

JOHN KERR

INDUSTRIAL OEMs

Waiting is the name of the PS/2 game

Industrial OEMs are looking for software, demand and market acceptance before committing to IBM's Personal System/2

By Anne Knowles

To hear original equipment manufacturers tell it, IBM's second generation microcomputer is just another piece of hardware. IBM's Personal System/2 presents some problems, they say, but none that cannot be overcome. Interfaces will have to be redesigned for IBM's new proprietary bus, called the Micro Channel, but that won't be too difficult. The PS/2, which contains less slots for add-in boards than its predecessor, houses enough slots for most OEM purposes. And IBM's switch to 3.5-inch media presents more of a headache than a real obstacle.

So, why the lack of enthusiasm? Big Blue made it easier to buy and resell its new personal computers than many had anticipated. The lukewarm reception to IBM's PS/2 among industrial OEMs, instrument makers and computer-aided engineering (CAE) vendors is not due to disinterest. On the contrary, many technical OEMs assume their customers will eventually migrate to the new computers.

But the question is when. Rather than rushing to market with products based on the PS/2, many OEMs are taking a wait-and-see approach. And what many OEMs are waiting to see is software.

"We won't introduce anything until OS/2 comes out," says Michael Thiemann, vice president for marketing at Summation Inc., an automatic test equipment supplier in Kirkland, Wash. OS/2, the operating system developed by Microsoft Corp. of Bellevue, Wash., will not be unveiled until the first quarter of 1988. It is expected to overcome some of the limitations set by MS/DOS, the operating system which runs on IBM PCs. But some OEMs question when OS/2 will be fully functional.

PC growth in the U.S. manufacturing market

Source: Dataquest Inc.

"The first version doesn't address the needs of the market," says Don Richman, director of marketing at CASE Technology Inc., a Mountain View, California-based CAE vendor. "It won't provide true multitasking," or the ability to run numerous programs simultaneously, contends Richman. "It makes more sense to support Release 2," says Richman.

The multitasking difference

"Multitasking is what is going to really make a difference to us," says Mike Todd, marketing manager for John Fluke Manufacturing Company Inc.'s manufacturing and R&D applications group. Fluke, which once resold the PC as a test instrument and for data-acquisition applications, now only supplies software driver packages, or toolboxes, which aid customers in the use of the PC as an instrument controller. But because moving its current software over to a new operating system is a "tedious process," says Todd, and because "there hasn't been much demand for it," Fluke plans to wait for market acceptance of the PS/2 before formalizing its plans.

Vendors are not only waiting for OS/2 but for applications written for the new operating system. Existing application packages should run on the first release of OS/2 with little modification, says Curt Grina, vice president for marketing at Centec Corp., a Reston, Virginia-based supplier of manufacturing software written for the PC which runs MS/DOS. "The real task," says Grina, "comes with the second version [of OS/2]. Like everyone else," says Grina, "we're impatient."

"Driving acceptance of the PS/2 is availability of software," says David Penning, an analyst with Dataquest Inc., San Jose, Calif. Hardware, at least on the factory floor, is not the issue. "There is not much need for functions above what an XT can do," says Penning.

Jim Flanagan, marketing director for Analog Devices Inc.'s industrial automation division, agrees. Flanagan does not foresee potential demand for the PS/2 coming from Analog's existing customers that are content with their current systems based on IBM's PC AT. "At this particular point in time, there is not much demand," he says. Demand for the PS/2, if and when it comes, says Flanagan, will probably emanate from new customers.

Analog's Macsym 120, which the company no longer sells, was based on IBM's industrial PC. Currently, Analog offers board-level products for IBM PC ATs and XTs used in data acquisition. Analog is evaluating the PS/2 and plans to offer boards for the new system, "when appropriate," says Flanagan.

But Analog has not reached a decision whether to resell the PS/2. Analog and IBM have yet to reach an

agreement, says Flanagan, and IBM has yet to offer a ruggedized, or industrialized, version of the PS/2. IBM does not currently offer a ruggedized PS/2 for industrial OEMs although the company has supplied industrialized versions of its microcomputers in the past. "That," says Analog's Flanagan, "is the biggest waiting factor," holding up Analog's decision whether to buy IBM's new computers for incorporation into industrial automation systems. In the event that IBM does not eventually supply industrialized PS/2 models, Analog would consider buying compatible machines from another vendor.

Summation is also considering buying PS/2 clones if necessary. Even though the company would prefer to work with IBM, says Thiemann, up to 50% of its sales are ruggedized systems. "We prefer to work with IBM. It is our customers' first choice." Explains Theimann: "Only when they don't offer what we need do we turn to someone else." Today, roughly 25% of Summation's systems are based on hardware from COMPAQ Computer Corp., Digital Equipment Corp. and Wyse Technology Corp.

Allen-Bradley's plans

Allen-Bradley Co. of Cleveland sells three industrial systems based on IBM's AT and XT. During evaluation of the PS/2, the company is under a nondisclosure agreement with IBM and cannot discuss its plans for the new system. But according to Bruce Hammond, Allen-Bradley's manager of commercial marketing, the company designed IBM's new bus, the Micro Channel, into its high-end system based on the PC AT at the beginning of this year.

Currently, the company's three models based on IBM's PCs — the XT-based 6120, and the 6121 and 6122, both based on the AT — account for more than a third of Allen-Bradley's industrial computer division sales. But in the beginning of the year, the company introduced a line of board-level products for PCs. Inclusion of IBM's new bus in an existing AT-based product may be an indication that Allen-Bradley plans to emphasize its add-in board business rather than resell complete systems bought from IBM.

In the manufacturing market, says Dataquest's Penning, there is a movement away from programmable logic controllers to personal computers because PCs can do all that PLCs can do, and more. Allen-Bradley, which is No. 1 in the PLC market, says Penning, "certainly recognizes this trend."

Another trend, says Dataquest's Penning, is that customers are increasingly buying computers directly from computer manufacturers, rather than OEMs, and then buying add-in boards from industrial automation vendors such as Allen-Bradley. Accordingly, says Penning, Allen-Bradley will increasingly shift its product line to add-in boards.

In the OEM industry, the shift away from selling turnkey systems is most evident in the CAE market [ELECTRONIC BUSINESS, June 15 p64]. Cadnetix Corp., CASE Technology, FutureNet Corp., Personal CAD Systems Inc., Racal-Redac Inc. and Viewlogic Systems Inc. are all CAE or CAD vendors that either currently offer or plan to offer software for the PS/2. But CASE is the only one that currently provides turnkey systems, based on the AT, for customers. And the hardware portion of the company's business, says CASE's Richman, is down to 1% of sales. CASE is now deciding whether it would be wise for the company to resell the PS/2 at all. "We are doing a risk assessment within CASE on whether to support both hardware and software," says Richman. "Design automation markets," concludes Richman, "are turning away from bundled, turnkey systems."

PCs in the electronic CAE market

	1986	1987
Revenue ($ millions)		
Total CAE	$919	$1,036
PC share	22%	24%
Units		
Total CAE	14,327	16,900
PC share	63%	61%

Source: Dataquest Inc.

A blunt assessment

O'Neil Feltman, vice president for marketing at Cadnetix, in Boulder, Colo., puts it more bluntly. Reselling PCs, says Feltman, "is a bad way to make money. You lose 10% on inventory costs alone." And even though Cadnetix plans to supply software for the PS/2, the company is in no hurry to get to market. "There are two reasons why we're not busily working on that. One is, we're waiting for it all to settle out. The other is, you don't really need it in the CAE environment," says Feltman, because of servers. In addition, he says there are 3 million PC ATs installed with graphic capabilities that Cadnetix needs to address first.

The proliferation of customers that have bought PCs has affected instrument companies as well. While Hewlett-Packard Co. is still strong in instruments and DEC has a presence through OEMs, "the AT is becoming the computer of choice in the instruments market," says Galen Wampler, president of Prime Data, a market research firm in San Jose. "At least 80% [of PC-based test instruments] use IBM PCs or clones," says Wampler. "And in the majority of cases," says Wampler, "customers are moving to buying their own PCs," direct from the PC maker.

James Cavoretto, vice president for engineering at Northwest Instruments Systems Inc., agrees. Although the Beaverton, Oregon-based instrument company still sells systems, based on both COMPAQ and IBM hardware, "our actual selling of the computer is becoming less and less a portion of the business," says Cavoretto. The company's primary business has become plug-in cards and software.

Northwest Instruments hopes to decide this month or next whether to follow IBM's PS/2 path. "If the market moves in that direction we plan to provide support," says Cavoretto. "We are mostly driven by our customers and how well it is accepted in the engineering environment."

Cavoretto says that designing a new interface will not be difficult because, "it is not an exotic card." But, because Northwest customers require 5.25-inch hard disks, "we'll be faced with having to distribute software in two media," if the company supports the PS/2, which uses 3.5-inch disks. Even though Cavoretto is impressed by OS/2, the company is also evaluating Unix. "We'll be facing modification of our software in any event," says Cavoretto.

All of this reflection has given Northwest time to also consider alternatives. "Many companies that address the engineering enviroment are looking at workstations," says Cavoretto. Northwest is currently contemplating switching to either Apollo Computer Inc. or Sun Microsystems Inc. workstations.- □

DATABASE

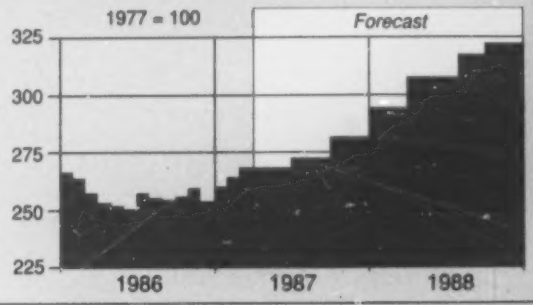
Recovery pick ups the tempo

The recovery in the market for computers, peripherals and related equipment (SIC 357) picked up the tempo in the first half of 1987. By this spring, production was running more than 7% ahead of the level at the low for this cycle, which occurred in June 1986. Employment was showing signs of stabilization after more than two years of almost uninterrupted declines. Domestic demand was improving steadily, as buyers stepped up their outlays for PCs, minicomputers, technical workstations and peripherals. Finally, there was continued evidence that the steep decline in the dollar since early 1985 was having a favorable effect on foreign trade. Exports by U.S. manufacturers were up an estimated 17.5% over year-earlier levels through May, approximately six percentage points above the comparable growth rate in imports. These data all indicate that the market recovery is firmly in place.

Compiled by LINDA STALLMANN

Computer industrial production

Seasonally adjusted index (SIC 357)

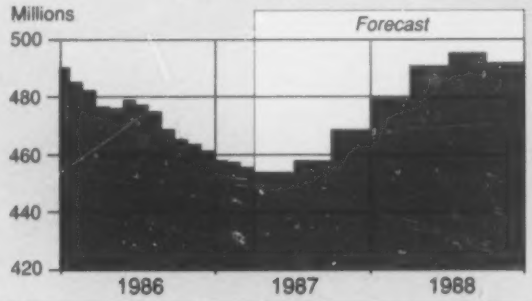


April 1987	March 1987	April 1986
268.4	268.7	252.9

Source: Federal Reserve Board; Forecast: Cahners Economics

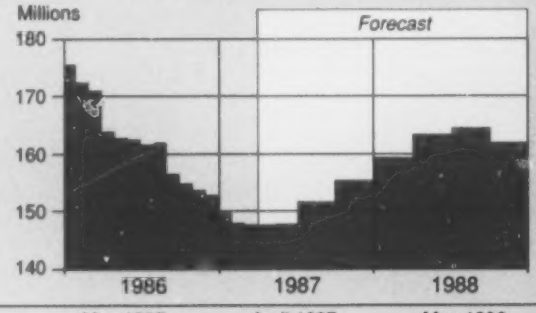
Computer industry employment

All workers



May 1987	April 1987	May 1986
453.9	453.9	476.4

Production workers

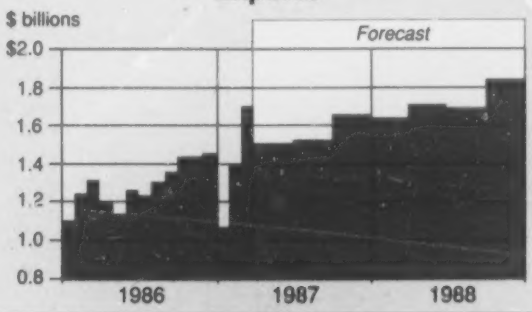


May 1987	April 1987	May 1986
147.7	147.5	162.8

Source: U.S. Department of Labor; Forecast: Cahners Economics

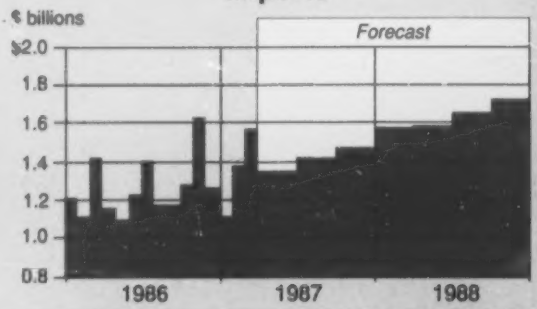
Computer exports and imports

Exports



May 1987	April 1987	May 1986
$1.519	$1.392	$1.139

Imports



April 1987	May 1987	May 1986
$1.411	$1.557	$1.157

Source: U.S. Department of Commerce; Forecast: Cahners Economics

INDUSTRY OVERVIEW

Board builders: Bringing the business back home

The landscape is changing on printed circuit boards. New technologies and philosophies mean survival of the fittest

By Bruce C.P. Rayner

With each successive boom-bust cycle, the overpopulated merchant board industry lunges closer toward maturity. The 1985-1986 downturn was no exception as some 100 companies out of a U.S. population of about 1,000 bit the dust. Compounding this Darwinian trend, some fundamental changes are beginning to appear in the PCB market: new technologies, new manufacturing philosophies and new exchange rates are redefining the rules of the game.

As the market improves in the latter part of 1987, the first signs of the success — or failure — of strategic plans that were made in 1985 and 1986 will appear. Strategies for survival differed markedly: some companies diversified; others consolidated; and those that could do so, invested heavily in capital equipment.

Certain catalysts promise to speed up the evolutionary process. Just-in-time manufacturing and surface mount technology are key components in the growth algorithm of PCB vendors and will play important roles in survival as the market begins to improve. The upshot is that the barriers to entry are getting higher. Production is now more capital intensive and long term vendor-customer relationships are becoming more popular as just-in-time sourcing takes off.

Most analysts that follow the printed circuit board market agree that the worst of the downturn is over. After plummeting from $5 billion in domestic production in 1984 to $3.9 billion in 1986, the market is showing signs of a rebound. Estimated at around $4.17 billion for 1987, average growth rates for the year range between 7% and 15%; a vast improvement over the contractions of the last two years.

Although high single-digit growth is a welcome improvement, no one in the merchant board business is willing to bet the factory on the continuation of this upward trend. While vendors have been seeing both bookings and shipments improve since the beginning of the year, false starts have occurred before.

"I would want to see [the recovery] sustained for a little longer before I say that the turnaround is indeed here," comments William G. Weiler, president and chief executive of Toronto-based Helix Circuits Inc. Helix had sales of $33 million in 1986 but has not seen a profit for two years. Most of Weiler's competition is equally unwilling to say the recovery is real. Andrew E. Lietz, vice president for sales and marketing at top-ranked Hadco Corp., headquartered in Salem, N.H., says that given the ups and downs of the last few years, Hadco's management remains "cautiously optimistic."

While industry leaders wallow in skepticism, analysts are convinced that the recovery is real. They point to the comeback of the computer industry and the reduction of offshore competition, especially from Japan, as evidence that the board market is on the mend.

Market researcher Philip Lapin, president of Electronic Marketing Consulting of Redwood City, Calif., believes that this recovery is on a much steadier path than that which was exhibited in the early part of the decade. Lapin puts U.S. PCB production at $4.17 billion for 1987 and forecasts 12.2% growth to $4.68 billion for 1988. "This is a subtle recovery and that is probably much, much better for the industry than the roller coaster ride in 1983-84," he says.

But, although a return to health seems likely, few expect prices to rebound. The reason is that there is still a lot of overcapacity in both the merchant and captive markets, as well as stiff competition for market share from the plethora of companies. "I think there is a lot of competition out there, so I don't know if prices will be going up, but at least they seem to be stabilizing," says Vincent Gatto, executive of the printed circuit group of Tyco Laboratories Inc., a leader in the merchant business.

Gnostic Concepts Inc., a Menlo Park, Calif., market research firm, estimates prices for one-sided and two-

sided boards to rise by a scant 3%, and only 5% to 7% for multilayer boards. Much of the increase is due to the higher cost of materials.

Harvey S. Miller, president of Kirk-Miller Associates, a Palo Alto, California-based market research firm that specializes in printed circuit boards, believes that capacity utilization in the United States has built from 70% during the recession to 85% this year. He estimates that, because $500 million in capacity disappeared during the past couple of years due to closures, demand and supply are now closer to equilibrium. Gnostic Concepts, however, claims that less than 70% of capacity is being utilized currently and will probably not reach much more than 75% by the end of the year. This jibes more closely with comments from top board makers.

Lower growth rates

Even though the astronomical growth rates of 1983 and early 1984 may never return, many PCB industry leaders agree with Lapin that the lower growth rates forecasted for 1987 and 1988 are better for business. With more stability, attention can be given to applications of new component technology, such as surface mount technology and, to a lesser degree, flexible and injection-molded boards. Instead of short-term crisis management, companies can concentrate on much needed long-term capital investment.

Lapin estimates that 40% of all boards produced in the U.S. market are destined for the computer market. Even though it is coming back slowly, the computer market represents a boon for board fabricators and assemblers. Similarly, he estimates that between 15% and 20% of all boards produced in 1987 in the U.S. market will incorporate surface-mounted components.

"Surface mount has been coming on very strong in recent months," claims Jonathan F. Kropper, president and chief executive of Hadco. Others in the industry agree that since orders for new designs started picking up at the end of the year, the demand for boards with surface-mounted components has been increasing steadily. "Eighty percent to 85% of what we are doing right now has a surface mount feature of some kind," says Michael Flatt, chairman of Continental Circuits Corp. of Phoenix, Ariz., a progressive company that grew 32% in 1986.

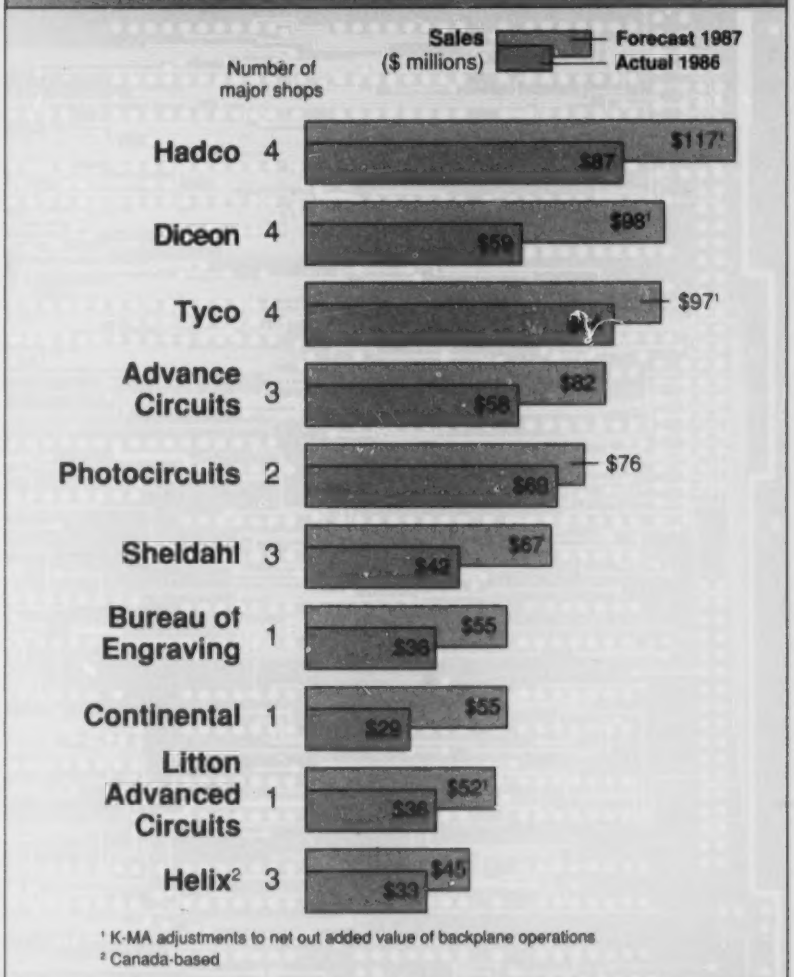
But Ray Pritchard, the executive director of the Institute of Interconnecting and Packaging Electronic Circuits (IPC), headquartered in Lincolnwood, Ill., the trade organization for the circuit board industry that claims 1,400 members worldwide, says surface mount is more talk than action at this time. "We get mixed signals about surface mount: everybody is interested but they don't all know how to design [the boards]." Until board designers come up to speed on surface mount technology, he says, sluggish growth will continue.

As surface mount catches on, Miller speculates that the relationship between the customer and the vendor will become closer. Higher levels of service and a closer working relationship will become necessary because the fabrication process is more complex than for the more conventional boards with holes. "That helps domestic sourcing," Miller comments. Instead of shipping board fabrication and assembly offshore, U.S. original equipment manufacturers will require their PCB makers to be close by.

The largest and fastest growing segment for 1987 and beyond will be multilayer boards. Gnostic Concepts estimates that MLB production in the United States will grow from 51% of the total, or $1.83 billion in 1986, to 56% or $2.64 billion by 1991, at a 7.6% annual growth rate. The highest growth will be in the flexible multilayer category.

Although still a very small part of the total PCB market at $317 million in 1986, Gnostic Concepts forecasts U.S. consumption of flexible boards will reach $449 million by 1991, averaging 7.2% growth annually. In 1986, only 12.3% of the flexible market was in multilayer boards, but by 1991, Gnostic Concepts estimates market

Top 10 North American independent fabricators of bare printed circuit boards



¹ K-MA adjustments to net out added value of backplane operations
² Canada-based

Source: K-MA Marketwise Services

share to reach nearly 20%. The annual growth rate of multilayer flexible boards will average 17.4% rate over the five-year period and grow from $39 million to $87 million.

Miller agrees that the flexible market will come on strong. Combining flexible and flexible-rigid hybrid boards, Miller puts the total size of the market at around $300 million in 1986, half merchant, half captive. Growth will be about 50% in 1987, he says, largely because of the growing number of applications in the commercial market that are using flexible boards.

Herbert W. Pollack, president of Methuen, Massachusetts-based Parlex Corp., maker of flexible and flexible-rigid boards, expects sales for fiscal year 1987, ended June 30, to increase by 25% over fiscal year 1986. Last year's sales came close to $30 million. The main growth in the flexible market, Pollack says, will be in the military area, where most of the flexible work historically has been done. The commercial market has not been tapped yet, he says, because it tends to much more cost sensitive than the military market. Parlex is concentrating on getting its costs down so it can compete with the commercial rigid market.

Total U.S. production of printed circuit boards

Merchant and captive production ($ billions)

	1985	1986	1987	1988	1989
Multilayer					
4-8 layers	$1.42	$1.34	$1.46	$1.67	$1.89
Over 8 layers	0.16	0.15	0.16	0.19	0.21
Premium boards*	0.27	0.27	0.32	0.38	0.45
Double-sided	1.31	1.18	1.31	1.46	1.59
Single-sided	0.18	0.18	0.19	0.20	0.21
Flexible	0.35	0.40	0.45	0.50	0.54
Paper-mat-composite	0.22	0.24	0.27	0.29	0.31
Total	**$3.91**	**$3.76**	**$4.17**	**$4.68**	**$5.21**

Totals may not be exact due to rounding

* Specialized laminates: polyimide, high frequency and other specialized resins

Source: Electronic Marketing Consulting

David Becker, manager of marketing and development at the Northfield, Minn., flexible circuit division of Sheldahl Inc., a leader in flexible board fabrication with $62 million in sales for the fiscal year ended in August 1986, says that 80% of the output from the Northfield facility goes to the commercial market. Customers include companies like AT&T, Ford Motor Co., Hewlett-Packard Co. and IBM. Both HP and IBM are important customers for the growing surface mount market, says Becker. Surface mount accounts for between 30% and 50% of all products, he claims.

Becker expects growing demand from the automotive industry over the next five years. "Weight and space are the factors that fit hand in glove with what flex does," he says, referring to automotive applications. In total, Sheldahl expects 10% to 15% growth in 1987. While flexible circuit boards will replace a small percentage

The polarization of PCB companies

For years the printed circuit board market has been an industry for the masses. Companies pop up like mushrooms overnight, some survive and flourish, others wither and die. Only a handful of merchant vendors are of any respectable size. Now that business appears to be picking up, the battle for increased market share is heating up. The companies to suffer the most, analysts say, will be mid-sized shops.

It has been suggested that the PCB merchant market will soon look like the double humps of a camel: one hump for the many small board makers (below $5 million) catering to the regional market; and another hump for the few very large ($100 million plus) merchant companies that will produce the large-volume capital intensive boards. Ray Pritchard, executive director of the Institute for Interconnecting and Packaging Electronic Circuits (IPC), the trade organization for the PCB industry with some 1,400 members around the world, says that about 80% of the industry is made up of companies with sales of less than $5 million a year. The small shops are here to stay, he says.

The segment of the market to suffer the most will be those in the middle range. The companies that have 30 to 40 customers but are having trouble competing with the big boys because of the lack of capital investment. They must either find a lucrative niche and milk it for all its worth or they are doomed to being a "me-too" shop and will ultimately get lost in the shuffle.

According to PCB market analyst Harvey Miller, president of Kirk-Miller Associates of Palo Alto, Calif., the recent evidence indicates that the middle tier of board makers has been dwindling. "A lot of the casualties in the last couple of years have been in the $10 [million] to $25 million group," he claims.

Many in the industry think this polarization trend will continue and will be made worse by another dip in business. Jack Mettler, president of Circuit Wise Inc., a $30 million North Haven, Connecticut-based PCB maker, puts it succinctly: "The guy who is doing $15 million with 40 customers is going to get cut up by the big guys and the little guys."

Keith Robbins, vice president of Photocircuits Corp. of Glen Cove, N.Y., a leveraged buyout from Kollmorgan Corp. in late 1986, believes that the worst of the shakeout is over but the trend to rationalize will continue. "There will be some fallout of the medium-sized shops — $10 [million] to $20 million — and the larger shops will continue to grow," he claims. Robbins speculates that the small shops will show resilience in the feast-or-famine PCB market because they can always find quick-turnaround and prototype business. □

of rigid boards in the future, most of the flex business will come from new applications.

Another new technology that is creating brand new applications is the injection-molded, or 3-D board. Although 3-D boards have potential in many applications, ranging from computers to automobiles, they have not yet caught on. So far, the major players in the 3-D market are chemical companies like E.I. du Pont de Nemours & Co. and ICI Americas Inc., both of Wilmington, Del., which have the plastics technology. But some PCB companies are also involved.

Last year, Circuit Wise Inc., of North Haven, Conn., a $30 million board maker, set up Mint-Pac Technologies Inc., a 50-50 joint venture with General Electric Co., aimed at high-volume applications of 3-D boards. Jack Mettler, president of Circuit Wise, says that so far, Mint-Pac is six months behind its planned sales schedule. The reasons include the extensive testing needed before bringing the product to market and the general reluctance of OEMs to accept change and employ the new technology.

Captive versus merchant

While companies like AT&T, HP and IBM maintain internal board shops, most of these big users also farm business out to merchants. Merchants, as a rule, claim to be more cost effective than captive shops and, in some cases, captives have cut back on their internal production. A case in point of a captive that opted to do more business outside is Unisys Corp., which recently closed two plants and will rely on the merchant market to supply an estimated $50 million in boards.

One beneficiary of the Unisys decision is the Bureau of Engraving Inc., a Minneapolis-based board maker. Sales for 1987 are expected to top $55 million, up from less than $40 million in 1986, says Darrell Chayer, vice president and sales manager for the Bureau. With top management changes and a high-tech niche carved in the four- to 22-layer board market, Chayer says the Bureau expects more business from Unisys as well as its other top customers, Digital Equipment Corp. and IBM.

But analyst Miller is quick to point out that Unisys is not initiating a trend. Instead, captives are attempting to spruce up their board shops to force them to stand on their own

Different strategies for the same goal

During the downturn, the leading merchant printed circuit board makers invested heavily while trying minimize their losses. Here is a summary of what three of the top 10 did to survive:

Hadco Corp. A few years ago, 50% of Hadco's business was with three customers: Digital Equipment Corp., Storage Technology Corp. and Wang Laboratories Inc. Because of tough market conditions faced by all three customers, Hadco suffered severely in 1985 and 1986, posting a net loss for the fiscal year ending Oct. 25, 1986 of a record $9.7 million. The company expects to return to profitability in fiscal 1987. The reason, says president Jonathan Kropper, is that Hadco's customer base has been diversified. "So if one customer catches a cold, we don't get pneumonia," he says. The result is that in 1986, Hadco had 26 customers that did over $1 million in board business.

Simlarly, Hadco has penetrated the European market with a highly automated facility in Ireland that will come on line by late 1988. And as Hadco looks to the future, Kropper anticipates "a significant opportunity" in the Pacific Rim. Currently, the company only has an agent in Hong Kong. "Simply stated, our strategy is to be in the market where our customers are located," says Kropper.

Continental Circuits Inc. At No. 8 in the lineup, 16-year-old Continental, a privately held Phoenix, Ariz., board maker, has been a shining example of how to run a board business through a downturn. Throughout the downturn, Continental has been profitable and between 1985 and 1986, the company grew sales at a 32% rate, says company chairman Michael Flatt.

The secret to Continental's success, says Flatt, was that in 1983-1984 the company positioned itself to focus on surface mount products. "We had something to offer that few people had," he says.

In an industry that is running at around 70% capacity, Flatt claims to be up in the 90% range. He says that sales will grow at an 83% rate in 1987 and will reach $53 million, up from $29 million in 1986. Since 1984, the company has increased its total floor space from 31,000 square feet to 75,000 square feet.

The most radical characteristic of Continental's strategy has been that it has no internal marketing or sales people. Since 1977, all the marketing is done by Jarko and Associates located right next door. "It is such a unified effort and has served us well in the downturn," comments Flatt.

Helix Circuits Inc. Through the downturn, 10th-ranked Helix expanded into four locations, two in Canada and two in the United States. The company closed its Montreal facility in June and moved most of its equipment to its Toronto headquarters. Because of the cost of capital expenditure, management decided to consolidate the two Canadian facilities, says William G. Weiler, president and chief executive of the company. Now, the company is concentrating on having one very strong division in Canada and two strong divisions in the United States: one in Irvine, Calif., purchased in April of 1985; and another in Woonsocket, R.I., that was recently completed. Plant capacity totals 141,000 square feet and business is divided 25% military and 75% commercial. Customers include the likes of Digital Equipment Corp. and IBM.

Because of the expansion, Helix posted record losses of $13 million for 1986 on sales of $33 million. But if the turnaround holds, Helix expects to return to profitability in 1987. "We feel pretty confident about profits in the short term and the long term," says Weiler.

Capacity is running at 60% of a total $120 million at this time because the Woonsocket facility is just coming on line. As for further expansion, Weiler says that stage is over for now. "We are in pretty good shape right now," he boasts. He expects the company will be profitable in 1987. □

and compete in the open market with the merchant board makers. Hewlett-Packard, a large captive board maker, is moving to make its board shop compete more efficiently for internal customers' business, Miller says.

More dramatic, and more relevant to merchants, is Tektronix Inc.'s printed circuit board division in Forest Grove, Ore., that is taking a bold step into the merchant marketplace. Miller estimates that Tektronix does about 25% of its business with outside customers.

Gene Hendrickson, general manager of Tektronix's PCB facility, says that top management made his division a profit center because of its excess capacity and its favorable cost competitiveness. Hendrickson says he intends to get up to a 50-50 mix of inside and outside business. The division's merchant share doubled in 1986 and will increase by 80% in 1987. "The importance of the customer has nothing to do with their name," he adds.

An embedded threat

While captives invade merchants and merchants invade captives on this continent, the international competition is eyeing North America hungrily. But, because of a weakened dollar, offshore competition has lessened over the past year. At the same time, the rate of offshore migration by U.S. companies looks to be slowing and just-in-time manufacturing and surface mount boards are demanding higher quality and closer relationships between customers and board vendors. All of these factors imply better conditions for onshore merchants. "I think the tide has turned," says analyst Miller.

Sources of PCBs imported into the U.S. market in 1986

($ millions)

	Embedded[1]	Bare boards
Multilayer	$128	$31.6
Double-sided	355	98.3
Single-sided	412	191.6

[1] Much of the embedded importation comes from Canada

Source: K-MA Marketbase Services

But there is more to the picture than the importation of bare boards for use in U.S.-made products. The real threat to domestic board makers comes from embedded boards — those boards, manufactured offshore and stuffed into foreign-made goods for sale in the United States. While bare board imports in the U.S. market amounted to $322 million in 1986, the embedded board imports for the same period were nearly $900 million, Miller estimates. Even though almost half of these embedded boards were one-sided, a growing percentage of them are two-sided and multilayer boards.

The main threat from embedded imports is the Far East; primarily Japan and the four Tigers — Taiwan, Hong Kong, Singapore and Korea. Miller estimates that between them, these five countries account for nearly 90% of all embedded boartd imports. With the value of the Japanese yen skyrocketing, the threat from Japan is abating somewhat. But with the four Tigers' currencies tied to the dollar, these countries still maintain a competitive price advantage in finished goods.

Keith Robbins, vice president of fifth-ranked Photocircuits Corp., a Glen Cove, N.Y., board maker, says that because of the falling dollar, he is seeing a little bit of an improvement relative to Taiwan and Japan. One indication of this, he says, is that old customers that disappeared two years ago are now reappearing because U.S. pricing is competitive.

Tektronix's Hendrickson agrees that conditions are improving because of the exchange rate, but insists that is no reason for U.S. PCB makers to rest on their laurels. Taiwan, he says, is the biggest threat: it has excellent capabilities, the country has been investing heavily and its people are well educated. He adds that Japan would be a major threat if it were not for the exchange rate. "In the last two years, [the Japanese] have doubled their circuit board manufacturing capability with the most sophisticated automation systems in the world," he says. A clear indication that they are not about to give up the fight for U.S. market share.

As for the European market, there is little penetration into the U.S. market from that part of the world, and equally little import from the U.S. Hadco has a presence in Ireland and IBM has a facility in Stuttgart, West Germany, says Roger Tyler, senior consultant with BPA Ltd., a market research firm in Britain, with a U.S. office in Cold Spring Harbor, N.Y.

Hadco's president Kropper says that Ireland was chosen because "we have a number of customers moving to Europe and we believe that we

Top 10 U.S. captive fabricators of printed circuit boards

Internal fabrication, not total usage

	Number of major shops	Percentage merchant sales	Forecast 1987 sales ($ millions)
IBM	3	0%	$375
AT&T	3	5%	$290
GM Hughes	6	7%	$190
Hewlett-Packard	4	0%	$85
GE/RCA	5	0%	$82
DEC	2	0%	$64
Rockwell	2	49%	$54
Tektronix	1	25%	$44
Cray	1	0%	$38
Unisys	2	0%	$35

ought to be there to service them." The facility will come on line by late 1988, will produce multilayer boards of "higher technology" and will operate on a stand-alone basis. "We believe it will be one of the premier facilities in the world, technologically speaking," boasts Kropper.

JIT anyone?

But in this day and age, technology is not everything. As analyst Lapin points out, the PCB market is largely a service business. Without on-time, quality deliveries, technology counts for naught. As capacity utilization increases and competitive hackles are raised, the merchants that can differentiate themselves by service will be the ultimate survivors. Comments Steven Fadler, vice president for marketing at the Advanced Circuitry Division of Litton Systems Inc., a Litton Industries Company in Springfield, Mo.: "It used to be that comments were made that [JIT] was a trend for the future. I think right now it is more and more becoming a matter of daily happenings."

All of the top players in the merchant market claim to be participating in some just-in-time programs with their suppliers. JIT refers to inventory arriving on the production floor just in time for production and involves a commitment to total quality in the sourcing and manufacturing of products.

One component of JIT that is affecting most board makers is the whittling down of the number of suppliers and the setting up of cooperative long-term relationships. Many have been reviewed by their customers over the last year or so. Some have lost business and others have picked it up. In this way, JIT is contributing to the natural selection process of quality fabricators and assemblers.

Most vendors that have the automation equipment and the resources for quality control education, such as statistical process control, are able to participate in JIT programs. The pressure is greatest for the smaller companies that do not have the funds for such tight quality control. □

Materials market: An upward movement

The materials market that supplies the printed circuit board industry is not an area of great volatility. Controlled by giants like E.I. du Pont de Nemours & Co., ICI Americas Inc. and Dow Chemical Co., there is little boat-rocking. Only when it comes to new technologies, particularly surface-mounted components and injection-molded boards, is there any flourish of activity.

Both the quantity and price of materials — laminates, resins and chemicals — are expected to show some slight upward movement in 1987. According to Richard Avins, a consultant with Strategic Analysis Inc. (SAI) of Reading, Pa., the total market will grow from $1.25 billion in 1986 to $2.3 billion by 1991 at an average annual growth rate of around 14.5%. Resins, used to make laminates, will increase in price in the order of 5% to 7% while chemicals and other materials should post price increases of 13%, he says. Gnostic Concepts Inc., a Menlo Park, California-based market research firm, agrees with SAI that material costs will increase gradually but steadily in 1987.

The first six months of 1987 have been pretty flat but Avins expects more robust activity in the second half as board makers begin to benefit from the rebound of the computer industry. Avins expects growth for 1988 to be in the order of 11%.

Prices of materials are firming up but price rises are not in the cards, says Joseph P. McGonnell, business director for Du Pont's printed circuit materials division. "At this stage, business looks pretty strong and volumes are beginning to rise," he says. Partnerships between the materials supplier and board makers are also becoming more common as the technology advances. With the finer lines, more layers and demand for higher quality and functionality, the material people become more critical, says McGonnell.

Most material makers accept that surface-mounted (SM) components will soon be the norm and they are gearing up to supply the materials for this market. Du Pont, a leader in imaging products, resins and cleaning chemicals, is looking to be a one-stop shop for all PCB makers' material requirements, both fabrication and assembly. "Assembly is clearly going to surface mount," says McGonnell, "and that affects not only the assembly but the way you construct a board."

As SM catches on, the demand for thermally stable resin systems will grow because as the population of devices on the board increases, the board itself needs to withstand higher temperatures during soldering. But even though these resin systems perform better than the common fire-retardant resin, FR4, used in most boards today, FR4 is still preferred because of its lower price.

Although injection-molded boards are a good idea, the market for them has not yet materialized. But that has not prevented Du Pont, General Electric and ICI from investing in the technology. Strides have been made in the last year that have brought the injection-molded boards closer to marketability, says SAI's Avins. But problems still exist in the surface mounting of components and the workability of high-temperature resins.

ICI Americas bought out LNP Engineering Plastics, a material supply company in Malvern, Pa., two and one-half years ago. LNP sells two high-temperature resins into the injection molding market that are expected to replace FR4. George Forczek, market development manager at LNP, says it is a growing market, particularly in telecommunications, military and automotive areas. □

U.S. consumption of materials and laminates

($ millions)

	1986	Forecast 1991
Materials		
Chemicals	$322	$592
Castings	140	258
Imaging materials	60	110
Total materials	**$522**	**$960**
Laminates	$730	$1,342
Total	**$1,252**	**$2,302**

Source: Strategic Analysis Inc.

SURFACE MOUNT

PCB makers face rising demand for SMT

What began quietly 10 years ago as a new manufacturing method is now a way of life in the printed circuit industry

By Valerie Rice

Surface mount technology (SMT), the province of consumer electronics manufacturers for the last 10 years, may just now be hitting its stride in mainstream semiconductor applications.

Some analysts say SMT — which involves soldering components directly onto a board instead of the through-hole technique (pushing the leads of each component through the board) — could account for 20% of the total semiconductor market by the end of this year. Others predict a figure of 37% by the end of the decade. By comparison, the Japanese have between 50% and 60% of their market in surface mount, primarily because of their strength in consumer electronics. In any case, watches — until now the biggest application of surface mount technology — will step down sometime soon, leaving the way clear for computers, defense systems and even automobiles.

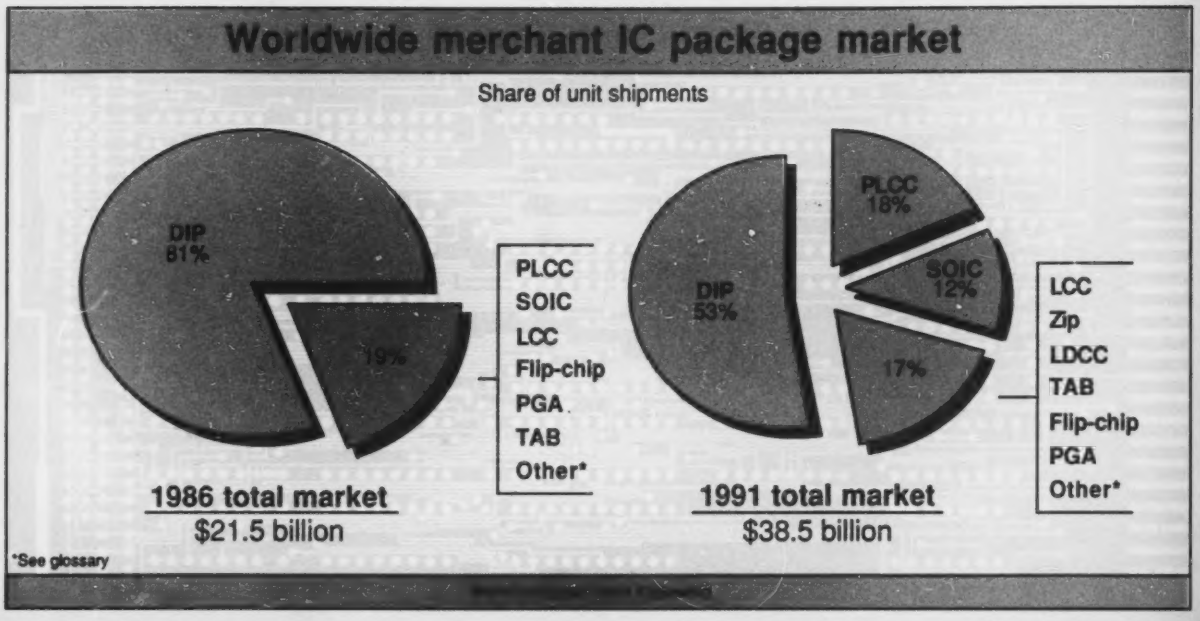
The customer is always right

"There's one primary reason we are doing surface mount technology," says Linear Technology's product marketing manager Robert Scott, "because customers are asking for it."

And customers are asking for it because it gives them distinct advantages in several different areas. SMT offers more functionality on a smaller board area. The smaller the board area, the less it weighs. In addition, the obvious space savings, combined with the other advantages, allows companies to create new products never before possible. For example, handheld televisions could not have been developed without surface mount.

"You couldn't do an embedded [disk] drive without SMT," adds Adaptec Inc. president John Adler. Adaptec, which does both chip design and sales, and board manufacturing, is in a unique position to leverage its SMT expertise. According to Adler, the company has done a "180° turnaround on surface mount. We do what our customers want. Customers are coming to us and saying, 'We want to buy in plastic leaded chip carriers [PLCC]. When can you ship it?' I'd be hard pressed to find any shipments we're doing today in through-hole, and in a year from now or less, we'll be totally out of the through-hole area." [There are several types of surface mount packages including plastic leaded chip carriers (PLCCs), leadless chip carriers (LCCs), small-outline integrated circuits (SOIC) and tape automated bonding (TAB).]

Lynn Crawford, advanced manufacturing director at Connor Periph-



erals, explains the advantage that SMT offers his company: "We can get more circuitry per square inch by utilizing SMT. It would be impossible for us to offer a disk drive with a controller without SMT."

One of the driving forces behind SMT has been the personal computer marketplace, with its push toward smaller footprints and increased functionality. SMT, with its reductions in size and weight, is the perfect solution. According to Texas Instruments Inc.'s SMT development manager Charles Hutchins, SMT allows two to four times the amount of memory to be placed in the same space as compared with through-hole packaging.

Using SMT equipment technology, boards can be put together at an unheard of rate, says Signetics Corp.'s SMT marketing manager Mark Carsten. An average-priced SMT pick-and-place machine will turn out half a million boards per hour, he says, in contrast with a through-hole machine, producing between 20,000 and 50,000 boards per hour.

The amount of equipment needed to manufacture SMT boards is also less than that of through-hole boards, according to Thomas Dunne, president of Phase 4, a Phoenix-based manufacturers' representative.

Therefore it is not surprising that several high profile product announcements this year — COMPAQ Computer Corp.'s new gas plasma display screen and IBM's new PS/2 — are taking advantage of SMT. Peripherals companies, such as AST Research Inc. in Irvine, and Hercules Graphics in Berkeley, Calif., are rushing to take advantage of this market with SMT devices designed to optimize these products.

Other applications for SMT are increasing as well. The military market, which demands that its products be small in size and weight, is moving toward SMT — as is the automotive market. Automotive companies were slow to catch on to SMT, but began two years ago using the mounting process in radios. Today, SMT has moved under the hood, as well as to flat-panel screen displays in the cabins.

Standardize or perish

One of the problems with all of this new development has been the lack of standards in SMT. With so many different packaging options, and so many different types of equipment, some industry players are feeling timid about entering the market without the assurance of long-term standards.

Darrell Paga, standards coordinator of the Semiconductor Equipment Materials Institute (SEMI) in Mountain View, Calif., says that he believes the industry "feels the lack of standards. The committees are backlogged, and it is hard to come up with a consensus opinion. It is hard to get anyone to agree."

Lack of standards is a problem for everyone, he says, primarily because it drives costs up. And costs go up for both customers and equipment vendors, when products and equipment aren't compatible, he says.

The standards issue is not a physical issue, but a design issue for Adaptec's Adler. "We spent a lot more time designing boards with decent manufacturing or yield in SMT than we did in through-hole. We redesigned the boards two or three times for high-yield manufacturing."

At Texas Instruments Hutchins says that standards in "evolving technologies are always a real concern." To offset that concern, TI must forecast carefully, because as Hutchins says: "If we aren't correct, we may develop tooling that's obsolete."

In addition to battles over equipment standards, there is currently discussion over which type of quad flat pack to use for the U.S. standard — the Japanese version which is metric and thin, or the U.S. version which is nonmetric and considered by some to be technologically superior because it is thicker. Quad flat packs resemble a plastic leaded chip carrier, but lack any of the standards surrounding PLCCs. One area of discussion currently is the lack of a consistent standard on lead spacing. Insiders suggest that the U.S. will adopt the nonmetric flat pack, leaving the Japanese and the Europeans with a standard of their own.

Other packaging standards are being discussed as well, Paga says, but they are hindered by the proprietary nature of many individual companies' packaging solutions.

Not surprisingly, no one is willing to say how quickly standards, both for packaging and equipment, will be set.

The equipment side

The advent of surface mount has created an entirely new industry for semiconductor equipment manufacturers. In fact, there was a Surface Mount Equipment Manufacturers Association (SMEMA) formed recently to address some of the standards issues for equipment manufacturers, as well as act as an informa-

A glossary of terms

DIP, dual in-line packaging, is a rectangular package with leads on two sides. Typically the leads are formed in a butted position.

PLCC, plastic leaded chip carriers, are four-sided square packages with leads on all four sides curling under the body of the chip.

LDCC, leaded chip carriers, are ceramic packages, similar to quad flat packs, and there is no lead standard.

LCC, leadless chip carriers, are ceramic packages with metal contacts instead of leads and the contacts do not extend beyond the body.

SOIC, small-outline IC, is a rectangular package with gullwing leads on the two longest sides.

TAB, or tape automated bonding, bonds the chip to the board by a strip of tape.

Flip chip or COB, chip on board, takes two forms. The chip can be bonded to the board and then wire bonded. Or the traditional flip chip approach can be used, with gold solder bumps on the chip contacts. The die is then flipped over to the board and soldered.

PGA, pin grid array, is a square package with typically 68 pins out of the bottom; it resembles a bed of nails.

Zig Zag single in-line packaging has leads out of one long side and is exactly the same as single in-line packaging except that every other pin is placed in the opposite direction.

Other methods include packages such as zig zag, other single in-line packages, and pad grid arrays, which are like pin grid arrays, but use pads instead of pins.

Source: Integrated Circuit Engineering

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Beyond surface mount

Some in the industry say that the next step in printed circuit board assembly will take the advantages of surface mount — the ease of placement and small size — and go one further, mounting chips on boards without the use of packaging. Charles Hutchins, SMT development manager for Texas Instruments Inc., calls this "bare chip mounting." The chip will be designed so packaging is not needed, and instead will be mounted directly on the board by solder, and then covered with a protective film.

The idea, Hutchins says, is simple. "Ten years ago silicon was very small when compared to the package. Today silicon is 50% of the package size, so it is not hard to see that 10 years out [from now] there will be no package, but just silicon."

Solutions such as "chip on board" or tape automated bonding (TAB), which have approximately 1% of the market now, will continue to gain market share. These mounting techniques are the first moves toward what Hutchins sees as a time when "silicon itself will be designed to be a standalone building block." □

tion clearinghouse for SMT equipment producers.

Surface mount equipment is certainly selling well. According to Phase 4's Dunne, 70% to 80% of his business in the last 18 months has been SMT related.

In fact, Dunne says that SMT equipment manufacturers have an advantage over through-hole systems in terms of sales. SMT equipment is less expensive in the long run, Dunne contends, partially because with through-hole more machines are needed to get the job done and fewer of those machines are automated. A pick-and-place robot handles it all, Dunne says, as well as taking up less floor space. Further space reductions are possible, he says, because the boards themselves are smaller.

Price is not a major consideration for Dunne's customers, he says, indicating that his biggest obstacle is customer ignorance. "Many companies are reluctant to put pick-and-place systems in because of information that is one to two years old. Two years ago there were only 500 parts available in SMT, and in one year that number grew from 500 to 5,000. I'm not sure about the count now. But it is outdated information that keeps people from changing over."

Not quite perfect

SMT is not without its detractors, however. Despite its obvious advantages, the technology, which has been around 10 years or more in consumer electronics, has been slower to gain widespread acceptance in the market than originally forecast.

One major issue, according to Integrated Circuit Engineering market research manager William J. McLean, is reliability. "Some manufacturers want to see 10-year lifetimes on SMT," he says. "It's difficult to get reliable information because the products have only been around two to three years. There is a barrier because there is no history. You don't know if problems have been identified. You can only overcome that problem with additional time."

SMT is also relatively difficult to design, from a computer-aided design perspective, says Dataquest Inc. analyst Isadore Katz. "In general the pin spacing is not the same as the through-hole format," Katz says. "On a CAD system, a designer must have another decimal place in accuracy in terms of complexity. This slows everything down."

Another problem, Katz points out, is testing surface mount boards. "To test each of the boards individually, you have to add test structures on the board, the so-called clamshells. This is not a trivial problem."

Despite the difficulties, Katz says that a recent survey indicated that 26% of all boards designed by CAD systems contained some SMT.

SMT boards are also harder to rework, says Connor's Lynn Crawford. In other words, Crawford says, it is much harder to correct a mistake. "It is a slightly more difficult manufacturing process, but overall, these are incidental problems," he says.

At Adaptec, Adler says he must keep an eye on his engineers so that they don't "go wild when designing an SMT board. Not all components are available in SMT. You have to be careful not to specify a need that doesn't exist." □

DEFENSE

Learning to cope with a budget-conscious Congress

Some analysts suggest only 3% to 4% growth this year and next, or zero growth in real terms for military electronics

By John Kerr

When defense contractors get together these days, it's not exactly party time. And as usual they're blaming Uncle Sam.

The gloom began a year or so ago as the Congress began to hack away at oversized defense budgets. It worsened last year when Washington saw fit to curb contractors' profits and also ruled that industry, not taxpayers, should bear the brunt of R&D costs on tomorrow's major weapons programs.

The result is arguably the toughest business environment military-equipment makers have ever known. "The overall outlook is not good," warns a market analyst at Hughes Aircraft Co. in Los Angeles. The stakes are higher and paybacks lower than ever before as a widening posse of regulators maneuvers defense contractors into increasingly competitive niches.

At least those are the blues that contractors are singing. According Paul Nisbet, an analyst with Prudential-Bache Inc. on Wall Street, the contractors are not faring as badly as they might want others to think. Figures from ELECTRONIC BUSINESS' top 50 list of defense contractors bears him out: Many have miraculously managed to increase earnings during the bad times.

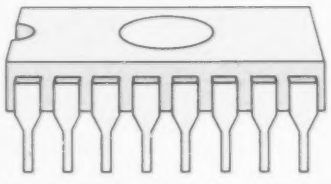
But the doomsayers' voices sing louder. The defense budget has also been hard hit by both deficit-nixing Gramm-Rudman legislation and by President Reagan's opposition to tax increases. A new report from Henderson Ventures, a Los Altos, California-based market research firm, forecasts that U.S. production of defense-electronics equipment will grow by only 4.4% this year, decelerating to a 3.6% pace in 1988.

Many analysts predict zero real growth in overall military-electronics revenue, stretching through 1990. Even formerly hot sectors like electronic warfare (EW) are stone cold. Only companies that have found the highlights in the no-growth picture — areas like command, control and communications, and integrated avionics — will manage to show respectable revenue gains.

Confirms Christopher Bernhardt, strategic planning director at the RCA Aerospace & Defense Group of General Electric Co. in Cherry Hill, N.J.: "If [a contractor] performs at an 8% a year growth rate he'll be doing well; if he grows 10% a year, he'll be doing phenomenally well."

"We are continuing to find procurements being stretched out," adds

Formerly hot sectors like electronic warfare are stone cold



Gene Ray, president of Titan Corp., a diversified San Diego defense-electronics firm. Ray indicates that contracts are being awarded three to four months later than his most pessimistic projections.

Insult to injury

Adding insult to injury are new government mandates that keep tight reins on contractors' costs — and profits. The Department of Defense (DoD) and industry are squaring off over Navy allegations that contractors' profits from military programs far outweigh those from their comparable commercial work.

In its 1987 annual report, Logicon Inc., a Torrance, Calif., command, control, communications and intelligence (C^3I) firm, explains: "The DoD has developed a new profit policy to be used in negotiating defense contracts for solicitations issued after October 18, 1986. This new policy, if fully implemented in its present form, will result in generally lower negotiated profit levels on new contracts to which the policy is applied. It will mitigate any improvement in profit margins gained by lowering of tax rates."

The consequences are daunting. Some contractors report that their profits may take as much as a 30% knock. Others say that it may take twice as long to make the same return on investment.

The DoD is also losing friends with over zealous scrutiny of contractors' costs. In its eagerness to show Congress that it will never again allow contractors to bill for $600 military toilet seats and the like, the Pentagon — industry executives complain — is nickel-and-diming military-equipment firms to the limit.

Says Titan's Ray: "We've had audits for everything under the sun." Officials at Calabasas, California-based Lockheed Corp. tell of auditors checking on executives' hotel spending limits, and more. According to the American Electronics Association (AEA), one of its member companies has had 102 individual audits in the last year. Another calculates that the government spent $300,000 in auditing its overhead of $500,000. Often, reports the AEA, the same prime contractor will audit the same departments at one subcontractor via differ-

ent programs. "It's a classic case of redundancy," says Jonathan Fleming, the AEA's senior manager of government procurement programs in Washington.

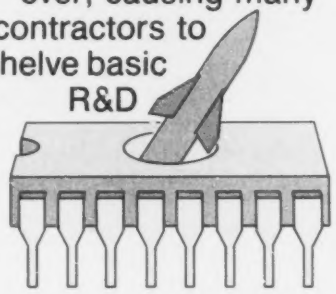
Ceding to the bureaucratic momentum behind the penny-counting, contractors are not optimistic about an early end to what they view as a wanton waste of their time and manpower. "It's something we're going to learn to live with," sighs one contractor. It seems so: the AEA claims that the Defense Contracts Audit Agency continues to recruit staff.

Making things more uncertain still is the ruckus created by the Competition in Contracting Act of 1985, another attempt by the DoD to make sure taxpayers get value for their money. The idea is that contractors will compete for major programs like the Advanced Tactical Fighter, with the most cost-efficient team winning the production work.

Although this is laudable in theory, it seems ludicrous to the defense industry. It means, some executives complain, that many contractors stake big bucks of their own on development, but only one team gets the payoff. And it is yet one more legislative roadblock for the industry. "Our biggest concern on profitability is the cumulative impact of all the reforms and regulations. It'll come home to roost in the 1989-1990 time frame," says GE strategist Bernhardt.

Military-electronics contractors are dealing with it in several ways. Many, like Honeywell Inc., are focusing only on markets that they feel they'll make money in; satellite maker, Detroit-based Ford Aerospace & Communications Corp. is concentrating on higher growth C^{3}I and tactical-weapons work. "We're having to be even more selective than before," says Donn Starry, Ford's executive vice president of its Washington operations.

Deciding where the investment dollars are to go is harder than ever, causing many contractors to shelve basic R&D



Other firms are bidding only on awards that they have a reasonable chance of winning and that they know will yield a proper return on the dollar. Hughes, now in General Motors Corp.'s fiscally conservative charge, admits that it bids with much less bravura than before.

Deciding where the investment dollars are to go is harder than ever. Many companies are now compelled to drop basic research in favor of more applicable studies. "You can't afford to do what I call hobby-shopping; R&D has to relate to projects on which you intend to bid," says Ford's Starry.

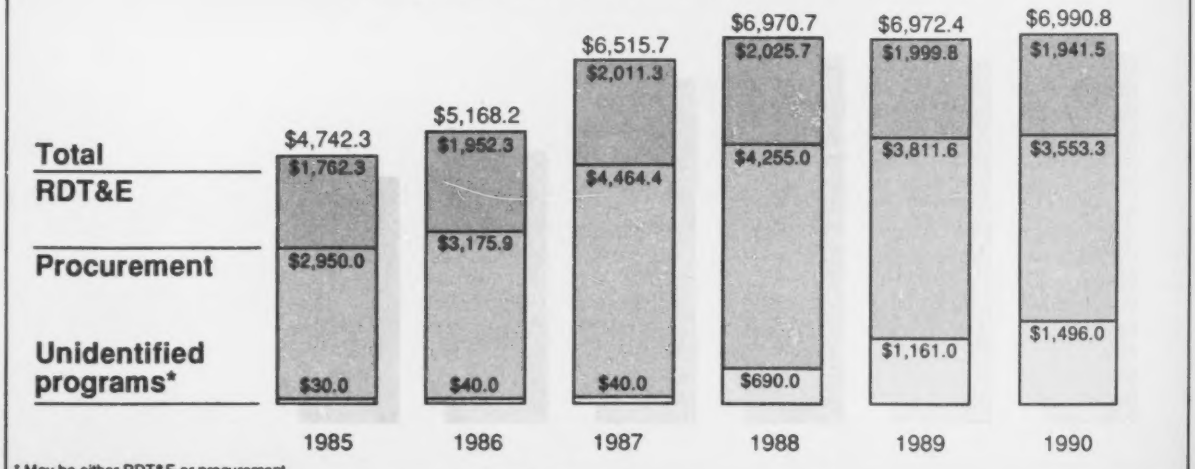
Critical mass

Contractors are also coping by consolidating, producing a marked restructuring of the industry. Where internal growth is not sufficient to achieve the "critical mass" needed to compete vigorously on key programs, acquisitions and mergers provide an answer. Seattle-based Boeing Co. bought out Sunnyvale, Calif., surveillance and countermeasures specialist ARGOSystems Inc. this spring, not long after EW supremo Loral Corp. of New York City took on Goodyear's aerospace and defense group.

Other moves include Chrysler Corp.'s $367 million bid for Texas C^3 specialist Electrospace Systems Inc., along with Beverly Hills-based Litton Industries Inc.'s purchase of Gould Inc.'s microwave products unit and of Harris Corp.'s solid-state microwave amplifier group. The restructuring will not stop there: giants such as Ford plan acquisitions. Meanwhile, companies like EW player Watkins-Johnson Co. of San Jose are

U.S electronics warfare appropriations

Fiscal year totals for all armed forces ($ millions)



* May be either RDT&E or procurement

Source: Frost & Sullivan Inc.

Top 50 defense electronics contractors

Fiscal year figures

Rank	Company	Defense electronics revenue ($ millions)	Total revenue ($ millions)	Total workforce	Defense electronics employees	Prime contract awards from the DOD ($ millions)	Fiscal year ended
1	GM Hughes	$6,120.0	$10,440.0	102,000	59,160	$5,069.3	12/86
2	Lockheed *	5,500.0	10,273.0	96,900	10,000	4,896.3	12/86
3	McDonnell Douglas	5,110.7	12,660.6	105,696	NA	6,586.3	12/86
4	Raytheon	3,888.0	7,308.0	75,000	40,000	4,051.6	12/86
5	General Electric	3,500.0	35,211.0	50,000	40,000	6,847.1	12/86
6	Boeing	2,900.0	16,341.0	125,000	13,000	3,556.0	12/86
7	TRW	2,670.0	6,035.9	78,556	27,408	1,052.6	12/86
8	Westinghouse	2,403.9	10,731.0	117,267	NA	1,713.2	12/86
9	Rockwell	2,368.0	12,295.7	121,000	20,000	5,589.7	9/86
10	Unisys	2,200.0	7,432.4	96,000	26,000	1,896.6	12/86
11	IBM	2,121.0	51,250.0	403,508	NA	1,359.2	12/86
12	Grumman	2,074.2	3,440.1	32,000	NA	2,967.5	12/86
13	Litton	2,069.0	4,521.0	55,500	20,000	1,663.3	7/86
14	Martin Marietta	1,901.0	4,752.5	68,500	15,000	2,935.4	12/86
15	Honeywell	1,800.0	5,378.2	78,000	NA	1,846.4	12/86
16	Texas Instruments	1,700.0	4,974.0	77,270	NA	1,434.9	12/86
17	Textron	1,609.0	5,023.3	72,000	NA	1,671.0	1/87
18	Ford	1,500.0	62,715.8	382,300	NA	752.1	1/87
19	Singer	1,370.1	1,725.2	28,000	23,600	985.8	12/86
20	Allied Signal	1,332.0	11,794.0	137,000	16,500	1,042.8	12/86
21	ITT	1,300.0	17,400.0	123,000	16,000	799.4	12/86
22	Teledyne	1,220.0	3,241.4	44,800	18,000	487.6	12/86
23	General Dynamics	1,200.0	8,892.0	105,400	NA	8,013.0	12/86
24	Northrop	1,200.0	5,608.4	46,800	NA	742.0	12/86
25	Eaton	1,052.0	3,811.6	43,000	9,285	1,068.1	12/86
26	E-Systems	1,050.1	1,145.5	15,000	13,270	192.1	12/86
27	GTE	936.9	15,111.5	157,000	NA	1,041.2	12/86
28	Harris	828.2	2,216.6	26,700	7,000	541.6	6/86
29	United Technologies	700.0	15,699.2	193,500	NA	3,527.0	12/86
30	Loral	634.0	663.8	8,100	6,480	377.0	3/87
31	Magnavox	565.0	665.0	8,880	7,605	NA	12/86
32	Emerson Electric	561.0	4952.9	60,700	NA	278.5	9/86
33	Computer Sciences	526.0	1,031.5	18,000	NA	288.1	4/87
34	Motorola	526.0	5,888.0	90,000	8,400	510.2	12/86
35	DEC *	500.0	7,590.4	76,860	NA	165.7	6/86
36	Eastman Kodak	462.0	11,550.0	121,450	NA	164.9	12/86
37	EG&G	450.0	1,145.1	23,000	5,000	NA	12/86
38	Tracor	441.4	632.1	10,500	7,400	193.7	12/86
39	Gould *	420.0	908.8	10,600	NA	300.4	12/86
40	Wang *	400.0	2,642.5	31,628	NA	NA	6/86
41	Control Data	341.6	3,346.7	34,409	NA	248.0	12/86
42	ATT *	300.0	34,087.0	316,900	NA	913.7	12/86
43	Mitre	271.9	362.5	5,500	NA	310.0	7/86
44	M/A-COM	255.0	577.5	9,027	3,100	NA	9/86
45	Olin	210.0	1,707.3	13,200	NA	306.6	12/86
46	Varian	205.0	891.1	11,600	NA	NA	10/86
47	United Industrial	201.3	272.5	4,050	NA	172.4	12/86
48	Hewlett-Packard *	200.0	7,102.0	81,000	NA	224.2	10/86
49	Logicon	196.5	198.4	2,456	2,456	NA	3/86
50	Watkins-Johnson	187.3	255.4	3,150	NA	NA	12/86

NA = Not available
* ELECTRONIC BUSINESS estimates

Source: ELECTRONIC BUSINESS

Notes on the top 50

ELECTRONIC BUSINESS each year ranks the top companies in defense electronics by contacting 150 leading defense contractors and asking them for their total revenue, defense electronics revenue, defense electronics employees and total employees. Many companies were forthcoming with the information; some were not. Much difficulty arises in obtaining numbers because a portion of each contract is often classified. (It seems that everyone has a Strategic Defense Initiative contract this year). Companies also often cite confidentiality agreements with the U.S. government as reasons for not breaking out their defense electronics revenue numbers.

However, not allowing a minor problem like nondisclosure to daunt us, ELECTRONIC BUSINESS picked over annual reports and pulled what numbers were available. In some cases we have gauged a company's 1986 defense electronics-related sales through estimates from Wall Street industry analysts.

Please note: No. 31, Magnavox Government and Industrial Electronics Co. (MAGIEC) is a wholly owned subsidiary of North American Philips Corporation. To qualify for high-level industrial security clearance for U.S. DoD contracts, MAGIEC's stock has been placed in a voting trust at the request of the U.S. DoD.

Overall, defense contractors racked up the usual billions in fiscal year 1986, but they have been hurt — or so they say — by the Gramm-Rudman-Hollings amendment which limits defense budget growth. Again and again in annual reports, companies cite changes in business because of DoD budgetary constraints and procurement policy changes. The effect of these changes on business means fewer new programs, increased competition for contracts, increased cost sharing for research and development, increased capital equipment investment and a higher level of unallowable costs.

Don't feel too bad for them, though. The top 25 contractors have defense electronics sales alone of over $1 billion.

NANCY MCSHARRY

considered good buys.

Another factor for participants to contend with is the growing internationalization of the business. U.S. firms now find feisty foreign defense contractors tackling them on home turf, and overseas markets closing off as others — notably Europeans — gain military-electronics expertise.

To keep overseas business alive, many U.S. firms are teaming with foreign counterparts. "The name of the game is collaborate or die," remarks Earl Washington, vice president for strategic marketing and international business at Rockwell International Corp.'s Electronics Operations in Anaheim, Calif.

Rockwell recently won a $500 million-plus award for submarine combat systems from the Royal Australian Navy. The deal was not one-way: Australia won jobs out of it, proving again that such "offset" agreements are increasingly central to international defense business. Last December saw one of the most obvious offset deals yet. Britain agreed to buy Boeing's E-3 early-warning aircraft, but only if it could gain 30% more value through technology transfer and jobs than it paid for the planes.

Although the odds seem stacked against military-electronics contractors, few are lining up for the soup kitchens yet. "If a company is looking at some area with a gleam in its eye, now's the time to go after it," explains Rockwell's Washington.

Besides, not every sector is belly-up. While contractors reliant on new aircraft and ship programs are eating dust, and even those building EW systems are tasting a slowdown, those working on missile programs and on C^{3}I fare better. According to market researcher Henderson Ventures, missile procurement is slated to increase by nearly 33% next year, while C^{3}I — a definite bright spot — will show an 8% boost in production this year and a 5.8% increase in 1988.

Antisubmarine warfare systems also remain hot. And although the controversial Strategic Defense Initiative, more popularly known as "Star Wars," did not win the funding this year that President Reagan had hoped for, contractors working on the development program still see good growth there.

TRW Inc.'s Electronics & Defense Sector in Redondo Beach, Calif., reports sound growth opportunities in integrated avionics systems for some of the newer aircraft platforms. TRW leads teams competing for the production phase of the Integrated Electronic Warfare System (INEWS) and the Integrated Communications, Navigation, Identification and Avionics (ICNIA) program.

Retrofitting work

Retrofitting work is becoming more and more of a factor in contractors' business plans as the armed services upgrade old equipment. But with increased scrutiny of the budgets, even some retrofit programs are slipping a bit.

Some of the strongest prospects for contractors lie in basic technologies — the semiconductors, sensors, software and systems-integration engineering central to every advance in defense-electronics equipment. Several players are watching with interest to see how Sematech — the consortium proposed as a DoD-backed chip-development resource — shapes up. One side effect may be sales of chemical vapor-deposition furnaces for use in semiconductor manufacture, which would benefit supplier Watkins-Johnson.

There also appear to be excellent opportunities for contractors adept at "black," or highly classified, activities. More and more defense-related work is disappearing underground: "The trend is still up," says one contractor. The Center for Defense Information, an independent Washington watchdog, claims that black defense spending is expanding: over $22 billion in the Pentagon's new 1988 budget is earmarked for black programs, a 16% rise over the record levels hidden in 1987 military plans where secret spending will top $19 billion, calculates CDI. □

COMPONENTS

Resistors: A reliable market nears $1 billion

The resistor manufacturers that have valued both quality and service are benefiting from an expanding market

By Carol Suby

The U.S. resistor market is expected to hover in the billion-dollar range for at least the next several years with U.S. consumption forecast to rise from $986 million in 1986 to $1.1 billion by 1991, according to research firm Gnostic Concepts Inc. in San Mateo, Calif. But, this minimal change in overall consumption cannot be equated with minimal change within the resistor industry.

This year issues such as quality and reliability and programs such as dock-to-stock and statistical process control have become the focus of major and not-so-major original equipment manufacturers (OEMs), says Gregory Littler, marketing manager for resistive products at Rohm Corp., an Irvine, California-based company that acts as a master distributor in the United States for Rohm Company Ltd. of Japan. Last year's just-in-time buzzword has given way to quality, service and communications, Littler adds.

These changes represent a part of an overall "renovation of American industry," says Lawrence Crum, director of marketing for Allen-Bradley's Resistive Products Division in El Paso, Texas. The total manufacturing culture has had to become more competitive, Crum points out. As a result, it's no longer "business as usual" in the resistor industry.

"Quality," Crum believes, "is the biggest single issue. [And] everyone's goals are the same . . . to get to zero defects." Moving in that direction, equipment manufacturers are setting acceptable levels of defective parts per million (ppm) for the components, including resistors, that they buy. And the margin for error is becoming increasingly thin.

Last year, AT&T was accepting resistors with defective rates of 200 ppm. That number has changed to 80 ppm for electrical defects and 100 ppm for visual and mechanical defects, according to Donald E. Gaddis, AT&T buyer of resistive devices, located at the company's Guilford Center Facility in Greensborough, N.C.

At GM's Delco Electronics Corp. in Kokomo, Ind., manager of purchasing John Stark says that the quality level of the surface mount resistors he receives is so high — averaging under 10 ppm — "we have found that we do more harm than good by conducting incoming inspection."

Service via communication

After quality, service has become the second new commandment in vendor/manufacturer relationships, and it usually comes in some form of communications. One of the fastest growing methods of communication between vendor and manufacturer — electronic data interchange (EDI) systems — are sprouting up everywhere, bringing the paperless office concept to the factory floor. These systems — used for order entry and acknowledgments, invoicing and, in some instances, for electronically transferring funds — generally consist of a network of personal computers and modems located at both vendor and customer locations. Third-party mailbox systems are used for transmitting the information.

Dale Electronics Inc. has EDI terminals at major customer and distributor locations. W.O. Means, corporate marketing director at Dale's Columbus, Nev., headquarters, expects the use of EDI systems will take off over the next two to five years, and believes that they will become, "the way to do business in the future."

In addition to changing how customers and suppliers communicate, the electronics industry is also overhauling its ordering practices. Contracts with guaranteed leadtimes are now giving way to release programs. A typical scenario, according to Rohm's Littler, might include a blanket two-year agreement that forecasts the need for a certain number of resis-

Nonlinears and networks are resistors' fastest growing segments

U.S. consumption of resistors by component type ($ millions)

	1986 value	Maket share	1991 value	Maket share	Average annual growth
Nonlinear	$137.4	13.9%	$233.5	20.1%	+10.2%
Network	184.6	18.7%	246.6	22.2%	+6.1%
Fixed	300.3	30.5%	325.3	29.3%	+1.6%
Trimmer	149.2	15.1%	153.5	13.8%	+0.6%
Potentiometers	214.7	21.8%	162.5	14.6%	-5.4%
Total	**$986.1**		**$1,111.4**		**+2.4%**

Totals may not be exact due to rounding

Source: Gnostic Concepts Inc.

tors. But the order would be filled in weekly, biweekly or monthly increments. And the number of units shipped each time would depend upon constantly updated forecasts provided by the customer.

For example, AT&T is currently putting into place its Business Resources Planning Program, which would provide customers with a long-range — approximately two year — planned order. Resistor vendors would then be provided with shorter term forecasts that would firm exact orders within eight to 10 weeks of shipping.

Vendor reduction

At the same time manufacturers are demanding better quality and service, they are also developing stronger relationships with a pared down number of suppliers. For example:

- AT&T, which bought approximately one billion resistors last year, buys 80% of those resistors from only a handful of suppliers, says AT&T's resistor buyer Gaddis.
- General Motor's Delco Electronics Corp., in Kokomo, Ind., uses no more than five vendors to supply in excess of 2 billion resistors a year, according to manager of purchasing Stark.
- Texas Instruments Inc.'s Industrial Systems Division in Johnson City, Tenn., has pared down its resistor supplier list to one preferred customer, according to TI buyer Suzanne Stacy. When "in a jam" Stacy will use other vendors. Otherwise, she prefers to purchase resistors from KOA Speer Electronics Inc., Bradford, Pa.

SMDs

Now that the computer industry is beginning to pick up and companies have more dollars to spend on capital equipment, the trend toward surface mount devices (SMDs) — leadless components that are placed on top of a printed circuit board rather than inserted — is back on track.

Although resistor manufacturers entered the surface mount arena at different times, all agree that SMDs will represent the major portion of their revenue some time in the 1990s. Last year, Bourns Inc.'s Network Division in Logan, Utah, was sampling its SMD products. Today, two surface mount network products are being offered with six-week leadtimes and another is in the prototyping stage, according to Bing Harding, president of the Network Division. In early 1986, CTS Corp., headquartered in Elkhart, Ind., introduced a surface mount resistor network. Since then, "production output has doubled, and redoubled," says James Long, national sales manager, at the company's Berne, Ind., facility. Although surface mount resistor networks represents less than 5% of CTS's total network output, Long expects that, "five years from now we will hit a crossover point where surface mounts will exceed leaded networks."

International Resistive Company Inc. (IRC was formerly TRW's Resistive Products Group) began pushing its broad line of SMDs two years ago. Boone, North Carolina-based IRC was the first company to offer surface mount wire wounds, according to Richard Paden, vice president, sales and marketing. Within the next two or three years, Paden expects surface mount will account for 35% to 40% of IRC's total revenue. Industry-wide, by the 1990's, "surface mount will probably account for half of all resistive components," predicts Dale's corporate marketing director Means. Dale has been offering a full catalogue of surface mount resistors since 1985.

Sprague Electric Co., which was first to introduce a surface mount capacitor, expects to be first again when it introduces a surface-mounted resistor/capacitor network by year's end, according to John Webb, marketing manager, thick film products at Sprague's Nashua, N.H., facility. Predicting a hefty growth rate of between 25% to 50% per year in surface mount networks, Webb expects that, by 1990, SMDs will account for 30% to 40% of total network demand. (Networks contain a number of resistors packaged into a single unit.) Currently Sprague, which has spent approximately $2 million gearing up for the manufacture of surface mount resistors, is "overwhelmed with demand for surface mount networks, but probably by the end of the year demand and supply will be in sync," says Webb.

For now, some manufacturers are facing surface mount delivery dilemmas. Texas Instruments' Industrial Systems Division just entered its first surface mount project which, this year alone, represents between 40 million to 50 million pieces. Also, "there are a couple of other [surface mount] projects coming down the pike," says buyer Stacy. Currently, however, Stacy says she is faced with leadtimes that she "cannot live with."

Meanwhile, it's a different story at GM's Delco headquarters. "Delivery to date has not been a problem and we don't expect it to become a problem," says manager of purchasing Stark. This is quite a feat for a company whose total surface mount requirement is in excess of 1 billion units a year. Stark attributes this smooth sailing to long-term planning that has been going on for several years with Delco's two surface mount resistor suppliers.

The winds of trade are shifting and those resistor vendors with domestic manufacturing are reaping a number

The fastest growth markets for resistors include communications and computers

U.S. consumption of resistors by markets ($ millions)

	1986 value	Maket share	1991 value	Maket share	Average annual growth
Electronic					
Government/military	$188.1	19.1%	$230.5	20.7%	+4.2%
Communications	148.9	15.1%	179.6	16.2%	+3.8%
Computer equipment	187.6	19.0%	224.9	20.2%	+3.7%
Industrial electronics	57.8	5.9%	67.6	6.1%	+3.2%
Consumer electronics	189.1	19.2%	215.2	19.4%	+2.6%
Business/retail/education	18.1	1.8%	18.2	1.6%	+0.2%
Instrument	107.7	10.9%	96.5	8.7%	-2.2%
Total electronics	**$897.4**	**91.0%**	**$1,032.0**	**92.9%**	**+2.8%**
Electrical/industrial	$88.8	8.9%	$78.9	7.1%	-2.3%
Total	**$986.1**		**$1,110.9**		**+2.5%**

Totals may not be exact due to rounding

Source: Gnostic Concepts Inc.

of benefits. For some time, Far Eastern suppliers have been the price leaders in commodity resistors. But the rise of the value of Japan's yen in relation to the dollar — which has been averaging ¥140=$1 — is putting the squeeze on vendors with large manufacturing bases in Japan.

U.S. firm Stackpole Electronics Inc., has manufacturing bases in both Taiwan and Japan. When Stackpole was setting contract prices last year, the exchange was ¥205 to the dollar, says Stuart Tugman, vice president of marketing at Stackpole. By the third or fourth month that figure dropped to about ¥180, and the percentage difference was absorbed by Stackpole. This Raleigh, North Carolina-based company is now looking to move some of its metal film resistor production from its Japan facility to its Taiwan facility, which currently manufactures carbon film products, exclusively.

Perhaps hardest hit are Japanese firms such as KOA Speer Electronics Inc., the U.S.-based resistor operations for Japan's KOA Denko Company Ltd., which imports all of the resistors it sells from the Far East, 50% of them coming from Japan. Lester Rice, vice chairman of KOA Speer, describes the yen situation as "very serious" and says, half jokingly, that as a result of the yen's soaring value he is "almost half dead." KOA is looking to develop manufacturing facilities in mainland China, where exchange rates are a lot more controlled, according to Rice.

Indeed, on some spot purchases, Gaddis at AT&T is seeing some price increases — between 7% to 10% for Japanese firms and about 5% increases for some companies with American and/or European sourcing.

Such firming or rising of prices is only one indication that the worst is over for resistor manufacturers. Company revenues for 1987 are expected to increase by at least 6%, according to Tugman at Stackpole, to as much as 20% to 25%, according to Harding at Bourns and Thomas McKelvy, general manager, resistor operations at North American Philips' subsidiary Mepco/Centralabs in Mineral Wells, Texas.

Behind revenue growth is a resurgence of business within the computer and peripheral area, which is getting a boost from IBM's newly introduced Personal System/2 line of personal computers, suggests IRC's Paden. Meanwhile, Paden describes business from the automotive sector as "fairly steady." And the telecommunications sector, he adds, "has slowed down somewhat due to increased competition from European companies selling into the U.S. telecommunications market."

Orders from the military sector continue to be "fairly stable," according to Crum at Allen-Bradley, the primary supplier of carbon composition resistors to the military. □

Resistor makers restructure

Today, the resistor marketplace differs dramatically from what it was just three years ago, and key changes are expected to continue throughout the remainder of this decade. Resistor companies have been acquired, spun off, and, in some instances, acquired again. Analysts and vendors alike expect these consolidations to continue for some time, eventually leaving the industry with a handful of major suppliers with worldwide presence, and a smattering of small, niche-oriented companies.

The following list includes a number of companies that have experienced restructuring at some time during the past three years:

Allen-Bradley, Electronics Components Division, El Paso, Texas: In February, 1985, Rockwell International purchased Allen-Bradley Corp. for $1.65 billion. Even though there have been no major operational changes since then, Allen-Bradley's microelectronics operations, based in Greensborough, N.C., and the resistive products division, based in El Paso, Texas, have been consolidated into the Electronics Components Division, headquartered in El Paso.

CTS Corp., Elkhart, Ind.: During the fall of 1986, CTS was able to fight off an acquisition attempt by Dynamics Corp. of America by adopting a poison pill policy.

Dale Electronics Inc., Columbus, Nev. and **Vishay Intertechnology Inc.,** Malvern, Pa.: In 1985, Vishay formed a joint venture with a British investment firm, Mezzanine Capitol Corp., to purchase Dale Electronics for $93.8 million. The joining of Vishay — a $57 million company known for its high-end, precision resistors — with Dale — a $127 million company with a broad resistor product line and strong distribution channels — makes Dale/Vishay the largest fixed resistor company in the U.S.

International Resistive Company Inc. (IRC), Boone, N.C.: Acquired by TRW in 1968, and renamed TRW's Resistive Products Group, IRC was sold off in November 1986, and reclaimed its name. Crystalate Holdings Plc — a British company that also owns Welwyn Resistors — purchased IRC for $30.6 million. This sale not only broadens IRC's product line, it also increases the company's geographical market presence.

Mepco/Centralab Inc., Mineral Wells, Texas: Owned by North American Philips, Mepco/Electra, a manufacturer of passive components, was merged in March 1986, with Centralab, a manufacturer of capacitors and switches, as a part of N.A. Philips' move to consolidate many of its U.S. acquisitions. In June of this year another N.A. Philips subsidiary that manufactures resistors — Ohmite Manufacturing Company — was merged into Mepco/Centralab.

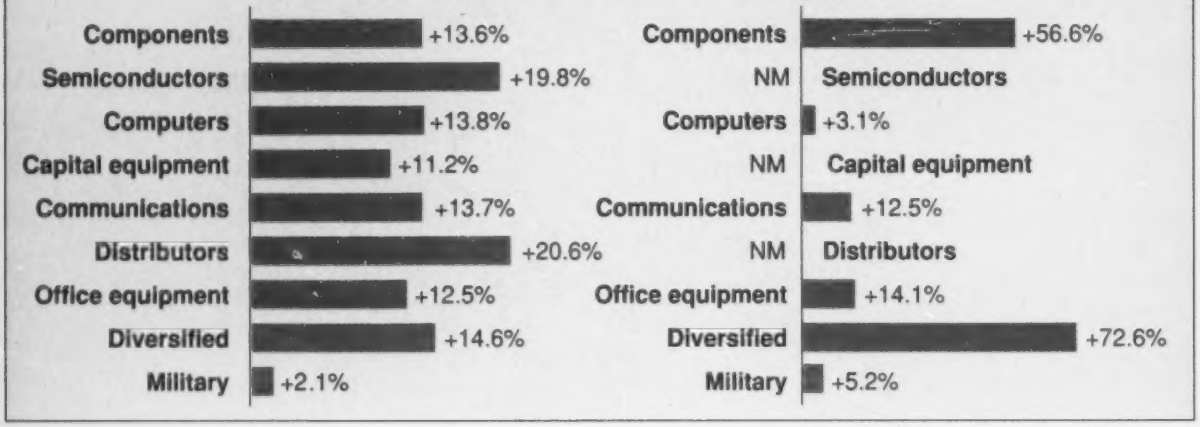
Sprague Electric Co., Lexington, Mass.: At press time, Sprague Electric Co. was in the process of being merged with another subsidiary, Solid State, renamed Sprague Technologies Inc., and spun-off from parent company, Penn Central Corp., Greenwich Conn.

Stackpole Electronics Inc., Raleigh, N.C.: Formerly part of the Components Division of Stackpole Corp. — a family-owned diversified company — Stackpole Electronics Inc. was sold off in August 1986, due to a family decision to pull out of the electronics industry. Charles Hill, company president, and several investors purchased the company for an undisclosed amount. □

Financial results of leading U.S. electronics companies

Industry segment averages

Percentage change from 2nd quarter of 1986 to 2nd quarter of 1987



	2nd quarter figures				Year-to-date figures				
Components (other than semiconductors)	Revenue 2nd quarter 1987 ($ millions)	Change from 1986	Profits 2nd quarter 1987 ($ millions)	Change from 1986	Revenue year-to-date 1987 ($ millions)	Change from 1986	Profits year-to-date 1987 ($ millions)	Change from 1986	Quarter ended
AMP	$585.9	19.0%	$62.5	47.8%	$1,111.7	17.6%	$116.7	53.6%	June 30
AVX	61.7	21.0%	3.8	NM	121.7	24.7%	7.3	NM	July 4
Augat	78.3	20.4%	2.8	0.4%	153.5	18.6%	6.4	39.6%	June 30
BRIntec	86.6	6.7%	2.5	-49.4%	167.0	5.0%	3.7	-55.4%	June 30
CTS	65.1	11.8%	2.1	NM	127.5	8.1%	3.6	NM	June 28
Kollmorgen	74.0	-17.9%	-2.1	NM	146.4	-16.4%	-2.4	NM	June 30
Segment composite	**$951.6**	**13.6%**	**$71.7**	**56.6%**	**$1,827.8**	**12.5%**	**$135.3**	**55.4%**	
Semiconductors									
Advanced Micro Devices	$192.4	25.0%	$4.1	NM	$362.5	18.0%	$0.8	NM	June 28
Intel	439.0	43.8%	46.5	NM	833.5	42.7%	55.0	NM	June 30
LSI Logic	59.9	24.9%	0.3	-66.5%	115.0	23.3%	2.4	-32.3%	June 28
Texas Instruments	1,371.6	10.2%	32.9	167.5%	2,643.5	10.6%	7.7	NM	June 30
Western Digital	140.3	59.4%	13.4	67.9%	262.3	59.5%	24.2	68.4%	June 28
Segment composite	**$2,203.1**	**19.8%**	**$97.2**	**NM**	**$4,216.8**	**19.2%**	**$90.1**	**NM**	
Computers, peripherals and software									
Amdahl	$341.0	62.9%	$31.0	1,044.7%	$659.5	61.0%	$56.2	996.8%	June 26
Apollo	132.2	49.6%	7.6	630.5%	255.6	50.0%	14.0	788.2%	July 4
Apple	637.1	42.1%	53.5	65.4%	1,212.4	41.4%	87.3	36.2%	June 26
Control Data	785.9	-5.1%	-5.6	NM	1,607.6	-1.0%	0.8	NM	June 30
Convergent	104.7	41.1%	0.1	NM	193.7	18.3%	-10.9	NM	June 30
Cray Research	124.9	-30.6%	19.6	-55.8%	339.1	5.3%	76.9	2.0%	June 30
Data General	313.6	-3.6%	-65.1	NM	628.8	-2.4%	-89.5	NM	June 27
DEC	2,669.1	22.7%	377.3	58.1%	5,079.1	23.8%	684.8	238.6%	June 27
IBM	12,798.0	4.3%	1,178.0	-9.7%	23,473.0	4.8%	1,963.0	-15.5%	June 30
Mentor Graphics	53.9	28.1%	4.7	107.9%	104.4	31.9%	8.9	113.3%	June 30
Micropolis	70.9	28.4%	6.8	53.3%	132.7	25.3%	13.0	59.0%	June 26
MiniScribe	80.5	84.2%	7.6	35.7%	141.9	68.7%	13.7	33.0%	June 26
Prime	236.0	12.1%	15.7	37.3%	457.8	12.4%	27.6	33.3%	June 30
Seagate Technology	250.1	76.7%	37.2	126.6%	517.1	92.6%	77.6	174.9%	June 30
Sun Microsystems	185.9	142.4%	10.9	98.1%	327.6	144.0%	21.1	137.3%	June 30
Unisys[1]	2,275.0	70.1%	121.2	59.1%	4,690.8	89.6%	231.4	151.0%	June 30
Segment composite	**$21,058.8**	**13.8%**	**$1,800.5**	**3.1%**	**$39,827.2**	**16.3%**	**$3,176.0**	**5.3%**	

NM = Not meaningful; company had a loss in the base year

[1] Last year's results were before the merger with Sperry

(Continued)

QUARTERLY SCORECARD

Financial results of leading U.S. electronics companies

	2nd quarter figures				Year-to-date figures				
Capital equipment	Revenue 2nd quarter 1987 ($ millions)	Change from 1986	Profits 2nd quarter 1987 ($ millions)	Change from 1986	Revenue year-to-date 1987 ($ millions)	Change from 1986	Profits year-to-date 1987 ($ millions)	Change from 1986	Quarter ended
Computervision	$136.5	14.4%	$1.4	NM	$276.4	19.0%	$2.4	NM	June 30
Fluke	51.0	-2.0%	2.6	-11.0%	103.5	-1.4%	5.2	-14.7%	June 26
GenRad	46.6	12.2%	-38.3	NM	94.9	15.0%	-39.7	NM	July 4
Teradyne	79.1	6.5%	-2.9	NM	158.1	5.7%	-6.8	NM	July 4
Varian	252.4	14.0%	4.3	NM	492.0	11.2%	8.2	NM	July 3
Segment composite	**$565.7**	**11.2%**	**-$33.0**	**NM**	**$1,124.7**	**11.2%**	**-$30.6**	**NM**	
Communications									
Andrew	$57.6	28.1%	$2.4	102.6%	$156.3	14.4%	-$5.4	NM	June 30
Avantek	52.2	6.3%	4.1	6.3%	103.0	11.3%	8.3	5.9%	June 20
Aydin	37.2	3.3%	2.4	23.2%	70.7	0.4%	4.3	16.0%	June 27
DSC Communications	77.2	-6.7%	2.9	-22.2%	154.0	-2.9%	5.3	-7.7%	June 30
Dynatech	82.4	14.8%	4.8	-20.9%	164.3	17.5%	9.3	-20.0%	June 30
General DataComm	49.4	5.1%	0.8	-26.8%	102.7	13.3%	2.5	64.0%	June 30
Northern Telecom	1,253.0	17.4%	77.6	19.6%	2,396.3	17.6%	137.7	19.7%	June 30
Paradyne	58.1	-13.5%	-1.5	NM	114.0	-14.4%	-3.9	NM	June 30
Segment composite	**$1,667.1**	**13.7%**	**$93.3**	**12.5%**	**$3,261.3**	**14.1%**	**$158.1**	**3.5%**	
Distributors									
Anthem	$46.9	67.7%	$1.2	38.0%	$91.3	62.5%	$1.9	11.0%	June 30
Arrow Electronics	150.5	14.1%	0.5	NM	294.7	13.6%	4.0	NM	June 30
Pioneer-Standard	57.7	11.9%	0.8	101.0%	115.0	13.0%	1.8	721.9%	June 30
Segment composite	**$255.0**	**20.6%**	**$2.4**	**NM**	**$501.0**	**20.0%**	**$7.6**	**NM**	
Office equipment									
NCR	$1,359.6	16.3%	$98.6	25.1%	$2,481.1	16.5%	$160.2	24.1%	June 30
Pitney Bowes	552.1	13.7%	44.6	17.2%	1,056.7	13.9%	85.6	16.8%	June 30
Savin	87.3	-8.2%	2.0	NM	176.2	-7.3%	3.5	NM	June 30
Xerox	3,600.0	12.5%	154.0	14.1%	6,950.0	16.0%	289.0	21.9%	June 30
Segment composite	**$5,599.0**	**13.1%**	**$299.2**	**20.2%**	**$10,663.9**	**15.4%**	**$538.2**	**24.9%**	
Diversified									
General Instrument	$280.1	79.7%	$12.0	344.4%	$521.0	65.2%	$18.8	120.0%	May 31
Gould	232.5	3.0%	5.9	-42.7%	460.1	1.3%	11.5	-53.6%	June 30
Honeywell	1,575.0	18.7%	54.3	24.0%	3,057.5	23.4%	98.0	22.2%	June 28
Motorola	1,639.0	9.3%	80.0	45.5%	3,185.0	12.2%	136.0	36.0%	June 30
N.A. Philips	1,066.2	0.2%	5.1	NM	2,171.6	3.8%	19.6	460.0%	June 30
Zenith	538.5	41.5%	0.3	NM	1,085.3	38.9%	1.3	NM	June 30
Segment composite	**$5,331.3**	**14.6%**	**$157.6**	**72.6%**	**$10,480.5**	**17.0%**	**$285.2**	**40.7%**	
Military									
E-Systems	$292.5	-3.0%	$10.3	-35.1%	$608.8	10.6%	$26.9	-11.1%	June 30
GM Hughes	2,622.8	-4.8%	140.8	5.9%	5,307.4	-0.1%	278.8	11.9%	June 30
Logicon	47.9	-4.7%	2.3	-4.2%	101.7	-2.1%	1.6	-68.3%	June 30
Loral[1]	317.8	108.2%	15.6	17.2%	532.5	47.5%	33.5	10.4%	June 30
Raytheon	1,917.0	4.9%	110.8	11.0%	3,668.0	3.2%	212.6	10.7%	June 30
Tracor	167.7	3.2%	7.5	0.2%	326.8	6.2%	14.8	-0.8%	June 30
Watkins-Johnson	62.4	-9.4%	3.8	-20.7%	128.5	0.7%	8.4	-9.5%	July 3
Segment composite	**$5,428.0**	**2.1%**	**$291.1**	**5.2%**	**$10,673.7**	**3.4%**	**$576.6**	**8.6%**	

NM = Not meaningful; company had a loss in the base year

[1] 1987 results include acquisition of Goodyear Aerospace Corp., now called Loral Systems Group